BIOSTRATIGRAPHY AND DIVERSITY PATTERNS OF CENOZOIC ECHINODERMS FROM FLORIDA

By

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I dedicate this to my parents, Walter and Norma Oyen, who have always expressed absolute confidence in my ability to succeed and supported all my endeavors without question or hesitation. I could not have done this without their support through all these years and I appreciate it more than they realize.

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KEY TO ABBREVIATIONS

FLMNH	Florida Museum of Natural History.
UF	University of Florida.
UF#	Invertebrate Paleontology fossil lot number, Florida Museum of Natural History, University of Florida.
USNM	United States National Museum.
USNM#	United States National Museum paleontology fossil lot number.
USGS	United States Geological Survey.
FGS	Florida Geological Survey.
TL	Test length (along anterior to posterior transect).
TW	Test width (at midpoint of TL).
PSL	Peristome length (along anterior to posterior transect).
PSW	Peristome width.
PSP	Peristome position (from anterior test margin to anterior peristome margin).
PPL	Periproct length.
PPW	Periproct width (at midpoint of PPL).
PPP	Periproct position (from anterior periproct margin to anterior peristome margin).
POSAP	Position of apical system (from anterior test margin to center of apical system).
ANLL	Anal lunule length (interior lunule length, along anterior to posterior transect on aboral side).
ANLW	Anal lunule width (interior lunule width on aboral side, at midpoint of lunule length).
ANLP	Anal lunule position (distance from anterior lunule margin to apical system center).
PD(I-V)	Pressure drainage channel span (maximum width, adoral surface; Roman numerals I-V indicate Loven ambulacral designations).
TWMX	Test width maximum.
LTH(1-5)	Longitudinal test height (at five equidistant points beginning at anterior test margin and proceeding toward posterior).
TTH(1-5)	Transverse test height (at five equidistant points starting at left test margin when viewing adapical surface from above).
PAL(I-V)	Petaloid ambulacrum length (aboral ambulacrum length, from apical system margin to maximum pore-pair position; Roman numerals indicate Loven designations for ambulacra).
PAW(I-V)	Petaloid ambulacrum width (aboral ambulacrum width, at midpoint of ambulacrum length, from outer pore-pair to outer pore-pair; Roman numerals indicate Loven designations for ambulacra).
THMX	Test height maximum.

AL(I-V)	Ambulacrum length (adoral surface ambulacrum, from peristome margin to test margin; Roman numerals indicate Loven designations for ambulacra).
IL(1-5)	Interambulacrum length (adoral surface interambulacrum, from peristome margin to test margin; Arabic numerals indicate Loven designations for interambulacra).
ALL(I-V)	Ambulacral lunule length (measured on aboral surface using interior length; Roman numerals indicate Loven designations for ambulacra).
ALW(I-V)	Ambulacral lunule width (measured on aboral surface, interior width at midpoint of length; Roman numerals indicate Loven designations for ambulacra).
ALP(I-V)	Ambulacrum lunule position (measured from center of apical system to adapical lunule margin; Roman numerals indicate Loven designations for ambulacra).

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Fossil echinoderms from the Middle Eocene through Pleistocene in Florida are described here in detail, including any previously reported species as well as taxa that are new records as a result of this study. Twenty-three formations from the state produced fossils belonging to four classes of echinoderms, including echinoids, asteroids, crinoids, and ophiuroids. Echinoids are distinctly more diverse and documented than the other classes in the state.

The diversity of echinoderms from the Cenozoic in Florida has increased significantly as a result of examination of fragmented skeletal debris and small size fractions of the sedimentary rock. Echinoid species diversity generated herein resulted in an increase from 68 species (reported in publications before 1994) to a current diversity of 97 species. These new additions include both newly reported stratigraphic records of a species from the state and new taxonomic records (i.e., undescribed species). An important result of the additional taxa recorded is the change in the echinoid diversity pattern over time.

Most newly reported taxa were found in Miocene (14 new records) and Pliocene (eight new records) formations. The diversity pattern thereby shows a dramatic increase in diversity from the Oligocene to the Miocene, rather than a drop in diversity as formerly documented.

Changes in the diversity pattern may be attributed to multiple biases in addition to species extinction and origination. Such biases include stratigraphic resolution of data, changes in stratigraphic nomenclature, amount of outcrop exposure and topographic relief, varying preservation potential in carbonate versus siliciclastic strata, unequal epoch duration in the Cenozoic units, taxonomic nomenclature changes (i.e., species versus subspecies identifications), fossil collector preferences favoring unbroken specimens, and substrate grain-size preferences of the echinoderm taxa. Analysis of such biases indicated collector bias, strata composition, and substrate texture were the most important factors ultimately controlling the diversity pattern in Florida's Cenozoic echinoderm record.

Finally, an analysis of allometric heterochrony patterns completed for echinoid species in the family Mellitidae showed the predominance of paedomorphic patterns of evolution. Such trends closely matched previously proposed models for r-selection styles in higher energy environments where descendant species ultimately inhabited.

CHAPTER 1
INTRODUCTION

General Overview

The fossil record of Florida is diverse and rich, particularly with regard to marine invertebrate groups such as the mollusks, echinoderms, and foraminifera; and the terrestrial mammals. Echinoderms in particular are usually well preserved, abundant, and an important component of Florida's Cenozoic fossil record. These fossils have been studied and documented in varying degrees for approximately 150 years, though no comprehensive study of all fossil echinoderms in the state has been completed until now. It is my objective in this study to present a taxonomic overview of all echinoderms from the Middle Eocene through the Pleistocene, and to provide specific diversity values (at stratigraphic unit and epoch level resolution) for this time range. Many taxa are discussed at the generic level herein because most of my new records are not yet described to species level and, furthermore, numerous taxa have subspecies that I believe need to be re-evaluated. New species descriptions will be published as part of a continuing program of investigation.

Previous Work

The echinoderms of Florida have been documented as parts of monographs or descriptive papers from various Cenozoic stratigraphic units. Most of the early papers were limited in their breadth of discussion to the echinoids however, with no references to other groups of echinoderms that were part of the formations or, at best, only general statements to the effect that sea star ossicles or possible crinoid ossicles were present. One of the first monographs to include a detailed description of known Florida taxa was by Clark and Twitchell (1915), in which they discussed all records of Mesozoic and Cenozoic echinoderms from the U.S.A. At the time of this work, relatively few echinoderms had been reported formally or described from Florida, so this monograph contained few records for the state.

Echinoids from Florida and other southeastern states were the focus of several of Cooke's major monographic works (e.g., 1941, 1942, 1959), including the most comprehensive biostratigraphic work on echinoids in the southeastern U.S.A. to date (Cooke, 1959). A geologist with the U.S. Geological Survey, Cooke worked extensively in the Coastal Plain of the southeastern U.S. describing the sedimentary rock, strata, and fossils in this region (including Florida). His work helped generate a foundation for both the paleontologic and stratigraphic framework of the state (e.g., Cooke, 1915; Cooke and Mossom, 1929; Cooke and Mansfield, 1936; Cooke, 1939; Cooke, 1945). Durham focused primarily on the western U.S. fossils and localities, but two of his papers (Durham, 1954; 1955) included significant references to Florida echinoids as part

of his revision and updates of the order Clypeasteroida. Fischer (1951) described the echinoid fauna found in the Lower Ocala Limestone (the stratigraphic unit formerly referred to as the Inglis Formation). Echinoderm microfossils, including the comatulid crinoids, were discussed by Howe (1942) as being a neglected group of fossils in the Gulf Coastal Plain region, but he did not figure or refer to any Florida crinoids in his work.

During the middle to late twentieth century, a new group of echinoderm paleontologists continued to collect and describe fossils from Florida and the surrounding states. One of the most prolific of these workers was Porter Kier. Kier published numerous papers and monographs on stratigraphic occurrences and taxonomic descriptions of echinoids from Florida, as well as other areas of the southeastern Coastal Plain and the Caribbean that have relevance to the Florida taxa. Among his numerous monographs, several have specific relevance to Florida fossils and particular value in taxonomic and biostratigraphic work, including 1) a revision of the cassiduloid echinoids (Kier, 1962); 2) descriptions of the Caloosahatchee Formation and Tamiami Formation echinoids of Florida (Kier, 1963); 3) a revision of the oligopygoid echinoids (Kier, 1967); 4) a description of Middle Eocene echinoids of Georgia, that covers concurrent species occurrences in Florida (Kier, 1968); 5) a descriptive work on the spatangoid echinoids of Cuba that, once again, involves species that are present in Florida as well (Kier, 1984); and finally 6) a discussion of life habits of modern taxa in the Florida Keys, that includes observations relevant to fossil taxa in the state (Kier and Grant, 1965).

More recently, fossil echinoderm work involving non-echinoid taxa in Florida included analyses of new occurrences of asteroids from the Eocene and Pliocene (Jones and Portell, 1988; Ivany et al., 1990); new records of juvenile ophiuroids found as fossils within seagrass concentrations in Eocene limestones (Ivany et al., 1990); and the first confirmed record of comatulid crinoids for the state (Oyen, 1995). Studies of echinoid substrate preferences and their associated distributions in Florida were published by Carter (1987, 1990, 1997), Carter et al. (1989), Carter and McKinney (1992), and McKinney and Zachos (1986), while new taxonomic records and stratigraphic occurrences were published by Oyen and Portell (1996) and Portell and Oyen (1997). Finally, the use of echinoids for biostratigraphic purposes has been discussed within the context of Eocene stratigraphy. Hunter (1976) suggested that based on her extensive fieldwork, she believed that the oligopygoid echinoids might serve as viable biostratigraphic markers for the Late Eocene limestones in Florida. Shortly thereafter, Zachos and Shaak (1978) formally proposed a biozonation based on the stratigraphic ranges of the three Florida species of Oligopygus, which resulted in becoming the best known and most widely used echinoid biozone for the state's strata.

Unfortunately, no attempt was made thus far to assimilate all the information regarding Florida records into a single paper. Therefore, it is my goal in the following sections to familiarize paleontologists with the current status of diversity values for all strata exposed at the surface in the state. I also interpret

diversity patterns and provide information regarding possible biases or sampling artifacts for the echinoderm diversity data in Florida.

Purpose and Goals

The primary focus of this dissertation is to improve the fundamental knowledge regarding stratigraphic distribution of all varieties of fossil echinoderms of Florida. As noted earlier, significant work describes and documents fossil echinoids in Cenozoic rocks of the state, but such work has slowed dramatically in recent decades. This means that the database for interpretations of diversity, extinction and speciation patterns, and paleoecology has become stagnant. Although topics of greater interest in the discipline of paleontology have shifted in recent years away from classic paleontology studies such as taxonomy and biostratigraphy, I believe it is important to continue to expand the essential knowledge of species diversity. Such data are critical to build models and solutions explaining any trends over time. The best interpretations and predictions can only be generated if work continues to build on the alpha-level taxonomy and diversity database; the "big picture" is absolutely dependent on the smaller pieces of the puzzle to make the picture clear. While collecting echinoderms over the past fifteen years, it has become obvious to me that many new species of echinoids, asteroids, crinoids, and ophiuroids are part of the fossil record in Florida. Although I am not proposing new species names for any "new" taxa that I or others have collected, I am providing detailed descriptions of these fossils to be used as the basis for

comparison and in preparation for the formal review process of publication after this dissertation. Therefore, my research is directed at providing the most current and most thorough description and discussion of taxa in the state since the work of Cooke (1959) and the works of Kier (mostly in the 1960s).

A second goal of my research is to interpret the diversity pattern for the echinoderms of Florida, with particular focus on the echinoids. How has the diversity pattern changed in comparison with what was previously known and published? What implications do any of these changes have for understanding the basis for trends in the diversity over time? All paleontologists recognize that taphonomic processes greatly affect their ability to clearly read the fossil record and interpret information such as ecological conditions or physiological characteristics of those former organisms of interest. Therefore, I provide possible reasons why the diversity pattern looks as it does by accounting for specific biases affecting the fossils and strata of Florida. As an example, the Paleogene stratigraphic units are predominantly carbonate rocks whereas the Neogene units are dominantly siliciclastic rocks. Preservation of fossils within the carbonate units tends to be better than that observed in the siliciclastic units. The diagenetic changes occurring in carbonates may be less destructive toward fossils in contrast to when they are contained within siliciclastic units. Does this situation have a significant impact on the diversity record of echinoderms in Florida, and if so, why? Questions such as this are explored and addressed in my research presented herein to fully explain the patterns that exist in the data.

Another goal of this dissertation is to provide a thorough and current summary of the nomenclature history, lithology, and physical characteristics of all of the stratigraphic units that contain the fossil echinoderms of interest. It is not my intent to justify or solve the myriad problems and disputes associated with various formations in the state. However, it is valuable to include these descriptions, at least from a practical perspective, so that the information is available for interested workers who may refer to this dissertation in the future. I prefer to consider this dissertation work to be a comprehensive monograph on the echinoderm paleontology and stratigraphy for the state. Inclusion of details regarding the sedimentology and stratigraphy allows my research to be a functional reference source for other researchers interested in Florida geology and paleontology.

Finally, a component of my research was directed at interpreting the allometric heterochrony patterns that exist in closely related Neogene and Recent species of echinoids of the family Mellitidae. McKinney produced most of the evolutionary interpretations for echinoids of Florida and the Caribbean to date (e.g., McKinney, 1984 and 1986, among others), though most of his analyses focused on Paleogene taxa. Are the patterns present in the Paleogene echinoids also present in the mellitids (that evolved in the Neogene)? Are the heterochrony patterns resulting from ecology-driven change similar to those patterns indicated by the Paleogene taxa? These were among the questions I considered when analyzing the fossil mellitid species of the Pliocene through the Recent strata of the state. The analysis of biometric data from the included species also provided

further insight into the taxonomic status of selected species of echinoids, such as Mellita quinquiesperforata, and the quantitative validity of proposed qualitative characteristics of the taxa.

Methods and Materials Studied

Fossils included in the database for this study were obtained from a variety of sources. I conducted fieldwork and collected Florida echinoderms for nearly 15 years, and incorporated the information gathered before and during my graduate studies at the University of Florida into this dissertation. As part of this research, more than 100 echinoid-bearing localities were sampled, including many sites that are no longer accessible. All specimens found during my study are now part of the research collection in the Invertebrate Paleontology (IP) Division, Florida Museum of Natural History (FLMNH), University of Florida (collection acronym UF), Gainesville. The IP Division at the FLMNH holds the largest number of fossil echinoderms from Florida. This collection serves as the primary data source for my work, as well as for other Cenozoic echinoderm workers in the southeastern U.S.A.

Additional sources of data regarding Florida fossil echinoderms include other museum and private collections and published records. I examined specimens in the Department of Paleobiology, U.S. National Museum (USNM) at the Smithsonian Institution; the Florida Geological Survey; materials collected and curated by Harold and Emily Vokes, formerly of the Department of Geology, Tulane University; the Jules DuBar collection; the collection of Burt Carter at

Georgia Southwestern State University; the Florida State University Geology Department collection; and the stratigraphic materials collected by Joe Banks and Muriel Hunter (formerly of the Coastal Petroleum Company) and the collections were used to assimilate my echinoderm data. Each of these listed collections (with the exception of the B. Carter and USNM collections) are now part of the IP Division of the FLMNH. Finally, many individual collectors donated specimens to the FLMNH and greatly improved my ability to add new information to the Florida fossil echinoderm database.

Some of the taxa collected were found by sieving micro-size fractions of poorly lithified sedimentary rocks, as well as through the production of silicone peels of external molds within the sedimentary rocks. Relatively few stratigraphic sections or localities were examined closely at the small sediment or fossil size range, and this provided some of the new records reported in this paper. To date, only two stratigraphic units (or portions of these units) were so sampled: the Lower Ocala Limestone and the Chipola Formation. Work continues in the FLMNH IP Division to sieve additional strata as well as to produce many more silicone peels to augment the original rock samples and fossils collected in the field.

Details regarding the methods applied to the biometric analyses for heterochrony interpretations are included in Chapter 5. However, the specimens representing the variety of mellitid species considered in that chapter were obtained from fieldwork, museum collections including those of the FLMNH IP Division and the Invertebrate Paleontology division of the USNM. All of the

specimens of modern echinoids examined and measured were collected during my fieldwork at the University of Florida's marine biology field station at Seahorse Key, located approximately 5 km southwest of Cedar Key, Florida, in the Gulf of Mexico. Additional background information and specific methods of data gathering are included where appropriate within subsequent chapters.

CHAPTER 2
STRATIGRAPHY OVERVIEW AND GEOLOGIC SETTING

Introduction

The stratigraphy of Florida is complex, partly due to the history of the evolving stratigraphic nomenclature and its relationship to fossil components in the rock. The purpose of this section is not to re-define Florida stratigraphy, but rather to synthesize the data regarding echinoderm-bearing formations and their compositions. The objective of this approach is to enhance our understanding of fossil echinoderm distribution in time and space. Therefore, I provide a general statement about each of the formations in Florida where echinoderms are found, along with references where interested readers may find additional information. Knowledge of the stratigraphic nomenclature used in the state plays a critical role in interpreting the biostratigraphic data presented herein, and thus is essential background information for this dissertation. The number of new stratigraphic and taxonomic records for the formations of Florida depends on how stratigraphic nomenclature is interpreted in the state. Unfortunately, many of the formations in the state were defined (at least in part) based on fossil content. This created problems according to the current guidelines for naming strata, i.e., the North American Stratigraphic Code (NACSN, 1983). Therefore, this chapter includes general statements regarding the lithology of formations and multiple references

for literature relevant to each of the formations included in my research. This provides at least a basic context for the biostratigraphy discussion that follows.

Eocene Stratigraphy

Echinoderms are present in both of the Eocene formations that are exposed at the surface at some location in the state (Figure 2-1). The Eocene strata have particular significance for analysis of echinoderm diversity because this highest diversity is recorded from these formations. The Middle Eocene Avon Park Formation is the oldest rock unit exposed at the surface in Florida. A second echinoderm-bearing formation, the Late Eocene Ocala Limestone, unconformably overlies the Avon Park. These carbonate units produce the most diverse echinoderm fauna of any stratigraphic interval in Florida, with the Ocala Limestone containing nearly all of the recorded taxa.

The formations are very pure carbonates (especially the Ocala Limestone) ranging from wackestones to grainstones, and non-carbonate grains rarely exceed 5-10% of the rock volume. The combined thickness of the formations ranges from only a few m to over 365 m in the subsurface (Chen, 1965). The stratigraphic nomenclature associated with these Eocene formations is still under debate, but the names provided herein are currently accepted as valid by the Florida Geological Survey and the U.S. Geological Survey. For more detailed descriptions of these units, see Dall and Harris (1892), Cooke (1915), Applin and Applin (1944), Vernon (1951), Puri (1953a), Puri (1957), Chen (1965), Hunter (1976), Jones (1982), Scott (1991), Oyen (1995), and Randazzo (1997).

EPOCH	STRATIGRAPHIC UNITS		
PLEIS.	Satilla Formation		
PLEIS.	Anastasia Formation		
PLEIS.	Bermont Formation		
PLIO.	Nashua Formation	Caloosahatchee Formation	
PLIO.	Intracoastal Formation	Jackson Bluff Formation	Tamiami Formation
MIOCENE	Peace River Formation		
MIOCENE	Shoal River Formation	Statenville Formation	Coosawhatchie Formation
MIOCENE	Torreya Formation	Chipola Formation	Marks Head Formation
MIOCENE	Chattahoochee Formation	Parachucla Formation	Arcadia Formation
OLIG.	Bridgeboro Limestone		
OLIG.	Marianna Limestone		
OLIG.	Suwannee Limestone		
EOCENE	Ocala Limestone	Upper Member	
EOCENE	Ocala Limestone	Lower Member	
EOCENE	Avon Park Formation		

Figure 2-1. Middle Eocene through Pleistocene stratigraphic units containing echinoderm fossils. This illustration is schematic only and is not intended to relate information regarding unconformities, hiatuses, or facies. Formations without echinoderms are not included here.

Oligocene Stratigraphy

The echinoderm-bearing Oligocene rocks of Florida include the Suwannee Limestone, the Marianna Limestone, and the Bridgeboro Limestone (Figure 2-1). These three formations are similar to the Eocene units in their carbonate-rich composition, although the non-carbonate mineral content may exceed 10% slightly more frequently than is true for the older strata. Lithologies of the strata range across the spectrum from mudstones to grainstones (Bryan, 1991), and also vary from poorly lithified facies to very well-cemented or partially silicified. The most pervasive stratigraphic unit is the Suwannee Limestone, and all echinoderms from the Oligocene are present in this formation. The thickest unit is the Suwannee Limestone, reaching a maximum of approximately 46 m in northern Florida and southern Georgia along the Gulf Trough (Bryan, 1991).

For additional information on stratigraphic nomenclature history, lithology, and distribution of these formations, readers should refer to Dall and Harris (1892), Guppy and Dall (1896), Matson and Clapp (1909), Cooke (1915), Cooke and Mossom (1929), Bryan (1991), Bryan and Huddlestun (1991), Huddlestun (1993), and Randazzo (1997).

Miocene Stratigraphy

Most of the research completed in recent years regarding Miocene lithostratigraphy for the states of Florida and Georgia was published by Thomas Scott (Florida Geological Survey) and Paul Huddlestun (formerly of the Georgia Geological Survey). Both Scott and Huddlestun produced detailed bulletins for

their respective state geological surveys in 1988, reviewing the history and current status of Miocene stratigraphy in Florida and Georgia. Even though their work improved and clarified the use of stratigraphic terminology within the two states, some points of debate still continue regarding the revisions they proposed. However, these disputes or scientific problems with stratigraphic unit names or lithologic definitions are not addressed in this dissertation.

Ten Miocene formations contain echinoderms within the state of Florida (Figure 2-1). Formation definitions and boundaries I use in this dissertation currently are accepted as valid units by the Florida Geological Survey. The large number of stratigraphic units prevents a detailed discussion of their composition and areal distribution, but references cited below contain such information. In general, the dominant lithology of the Miocene formations is more strongly siliciclastic in contrast to the older Oligocene and Eocene formations. Several of the Miocene units contain abundant carbonate beds, while others contain few carbonate-rich zones and primarily consist of grains of quartz, chert, and various clay and phosphate minerals. The total thickness of Miocene sediments exceeds 100 m in local areas of the subsurface of Florida (Scott, 1997).

Specific details regarding lithology, fossil content, areal distribution, and the historical evolution of stratigraphic nomenclature for the Miocene formations are available in previously published work. In addition to Huddlestun (1988) and Scott (1988), these works (listed chronologically) include: Langdon (1889), Foerste (1893), Dall and Harris (1892), Dall and Stanley-Brown (1894), Sloan (1908), Matson and Clapp (1909), Veatch and Stephenson (1911), Gardner

(1926), Cooke and Mossom (1929), Cooke (1936), Mansfield (1937), Cooke (1943), Cooke (1945), Parker (1951), Puri (1953b), Puri and Vernon (1964), Heron et al. (1965), Brooks (1966), Hunter (1968), Banks and Hunter (1973), Abbott (1974), Wilson (1977), King and Wright (1979), Huddlestun and Hunter (1982), Jones and Portell (1988), Portell (1989), Vokes (1989), and Scott (1997).

Pliocene Stratigraphy

The Pliocene stratigraphy of Florida is extremely complex and still far from clearly defined and accepted by all researchers working on these units. The unifying theme throughout the Pliocene, just as it is through many of Florida's Cenozoic intervals, is the use of fossils to help identify the formations. It is inevitable that formation descriptions include paleontological discussions, because some of the world's richest and most densely packed fossil beds are found in Florida strata (e.g., the Caloosahatchee Formation of south Florida). In some cases, bioclasts are more than 75% of the sediment component of the beds and biostratigraphers used fossil species to aid in stratigraphic descriptions. Therefore, stratigraphic boundaries and descriptions were debated in the past, and likely will continue in the future as research proceeds on the stratigraphy of the Pliocene Epoch in the state. This time interval has many fossil-rich zones, and five Pliocene formations contain fossil echinoderms (Figure 2-1).

The Pliocene units range in composition from dominantly quartz sand beds, to carbonate-rich layers, to shell beds with little matrix. Variation in lithofacies occurs within the formations, but in general, these units tend to be

higher in siliciclastic content than the Paleogene formations. Thickness of the Pliocene units also varies significantly, ranging from only a few meters (in surface and subsurface intervals) to over 100 m in the thickest sections (subsurface intervals only). Additional information regarding stratigraphic nomenclature history, lithology and unit descriptions, and fossil content is available from multiple sources. Examples of these (in chronological sequence) include: Heilprin (1887), Langdon (1889), Dall and Harris (1892), Matson and Clapp (1909), Sanford (1909), Mansfield (1924), Cooke and Mossom (1929), Mansfield and Ponton (1932), Mansfield (1939), Parker and Cooke (1944), Cooke (1945), Parker (1951), Puri (1953b), Dubar (1958), Dubar and Taylor (1962), Puri and Vernon (1964), Hunter (1968), Dubar (1974), Huddlestun (1976), Schmidt and Clark (1980), Huddlestun (1984), Schmidt (1984), Meeder (1987), Huddlestun (1988), Scott (1988), Lyons (1991), Missemer (1992), and Scott (1997).

Pleistocene Stratigraphy

Three Pleistocene formations in Florida have records of echinoderms, including the Anastasia Formation, Satilla Formation and Bermont Formation (Figure 2-1). Just as with the older fossiliferous units in the state, stratigraphic definitions and boundaries are under debate for the Pleistocene formations. The lithology of these units ranges from dominantly quartz sand with limited fossils in the Satilla Formation (Huddlestun, 1988), to interbedded quartz sands and coquinas in the Anastasia Formation (Scott, 1991), to a shell-rich, unconsolidated sandy marl in the Bermont Formation (Dubar, 1962). The thickness of the

Pleistocene formations ranges from less than one m in outcrop to nearly 38 m in the subsurface. Further details regarding stratigraphic nomenclature history, lithology, thickness of specific units, and fossil content is present in a variety of publications. Selected examples of relevant work (listed chronologically) include: Veatch and Stephenson (1911), Sellards (1912), Chamberlin (1917), Cooke (1926), Cooke and Mossom (1929), Cooke (1943), Parker and Cooke (1944), Cooke (1945), Parker et al. (1955), Dubar (1962), Vokes (1963), Olsson and Petit (1964), Olsson (1968), Brooks (1974), Dubar (1974), Blackwelder (1981), Kussel and Jones (1986), Huddlestun (1988), Scott (1988), Lyons (1991), Scott (1991), and Scott (1997).

CHAPTER 3
SYSTEMATIC PALEONTOLOGY OF FLORIDA ECHINODERMS

Introduction

The fossil echinoderms of Florida belong to four groups (classes), including the echinoids, asteroids, ophiuroids, and crinoids. Whereas fossil echinoids are diverse and abundant throughout the Cenozoic of Florida, a limited published record or description exists for all other groups. In fact, until Jones and Portell (1989) described the occurrence of Heliaster microbrachius in southwestern Florida, most published records of asteroids referred only to the presence of unidentified ossicles within several formations. A similar pattern is true for the crinoids of Florida, with only one detailed discussion (Oyen, 1995) of disarticulated comatulid crinoid ossicles of Himerometra bassleri and a second unidentified species. Even less is known about the species and distribution of ophiuroids within the state, with the best examples of fossil ophiuroids published by Ivany et al. (1990). No compilation of all fossil echinoderms from Florida exists, even at class and lower taxonomic levels. This report not only adds significant new information to the taxonomic database, but also provides a comprehensive, single reference source for biostratigraphers studying such fossils in Florida stratigraphic units.

Though it is not the goal of this dissertation to formally describe all new taxa of echinoderms presented herein, it is warranted to provide the taxonomic setting for the various groups of fossils included in the discussion. I have chosen to leave any formal species descriptions for future work. Herein I provide preliminary descriptions of all fossil echinoderms, collected by me or other researchers and private collectors, that are new to the biostratigraphic and taxonomic realms of the Cenozoic fossil record in Florida. However, I also have included formal generic and specific descriptions for all echinoderm taxa that have been identified and reviewed in a professional forum. Along with such descriptions, I include remarks regarding my interpretation of the taxonomic identifications that I have made and the justification for such, as well as how these newly reported echinoderms affect the overall biostratigraphic record and species diversity estimates for each epoch associated with the fauna. Finally, my descriptions of these fossils include terms stating the echinoids are small, medium, or large in size. In general, these size terms relate to a test length of approximately less than four cm in the small category, less than about eight cm in the medium size category, while those echinoid fossils larger than eight cm are considered large.

Each of the four echinoderm class-level sections are presented in a phylogenetic context rather than a stratigraphic context, and all formal descriptions are limited to genus and species taxonomic levels. However, due to the large number of species associated with the Florida echinoids, taxonomic information is presented in a phylogenetic context with additional subdivision by

epoch. Only limited discussion of these taxa is included with regard to diversity and taxonomic implications of these results. Detailed examination of diversity patterns, changes in the patterns as a result of these new data, biases associated with such patterns, and relationship to echinoderm patterns from the western Atlantic, Caribbean, and Gulf of Mexico are presented in Chapter 4 of this dissertation.

Class Echinoidea Fossils

Eocene Echinoids

Class Echinoidea Leske, 1778
Order Cidaroida Claus, 1880
Family Cidaridae Gray, 1825
Genus Phyllacanthus Brandt, 1835

Description: Test spherical or low, usually flattened above, sides arched. Areoles well separated, central part elevated, carrying prominent, non-crenulate primary tubercle. Madreporite conspicuously larger than other genital plates, encroaching on small periproct. Scrobicular tubercles conspicuously larger than other secondaries, usually with distinct elevation on side toward areole. Pores conjugate, but with wall elevated aborally. Primary spines cylindrical, thick, robust, with fine granules arranged in regular longitudinal series on shaft; cortex thick; primary radial lamellae (as seen in transverse section) arising in fanlike clusters from projecting portions of medulla. Secondary spines broad, flat, squamiform, closely adpressed. Globiferous pedicellariae without end-tooth.

Florida species: P. mortoni (Conrad, 1850).

Comments: The species occurs throughout the Ocala Limestone.

Phyllacanthus mortoni (Conrad, 1850)
(Figure 3-1, A-C)

Material examined: UF 66913 (figured test), UF 3270 (1136 radioles), UF 12993 (test with spines), UF 68683 (partial test).

Description: Test large. Apical system subcircular, larger than peristome. Ambulacra nearly uniform in width, ribbonlike; poriferous zones about twice as wide as the interporiferous zones; pores round or oval, conjugate; zygopores transverse, separated by a ridge; interporiferous zones granular. Interambulacra composed of about eight to ten tiers of plates, the median area somewhat sunken; plates wider than high; tubercles smooth, perforated; high; granules arranged in transverse rows separated by a groove. Peristome pentagonal, the angles truncated at the ambulacra. Spines decorated with longitudinal rows of spinelets. On some the spinelets are uniform in size; others have longer thornlike spinelets at regular intervals.

Remarks: Few nearly complete fossils of this species have been collected, but the preservation of test morphology normally remains good although fragmentation may have occurred. The species is relatively easy to identify, even when radioles are the only skeletal component present at a given locality.

Order Diadematoida Duncan, 1889
(Figure 3-1, D-E)

Florida species: Family, genus, and species undetermined.

Comments: The specimens were collected from the Upper Ocala Limestone in northern Florida and consist of one incomplete test (unavailable for

description) and several lantern components (figured). These fossils are important because they represent both a new stratigraphic record and, with high probability, a new taxonomic record for the state.

Material examined: UF 32929 (figured hemi-pyramids of lantern).

Order Phymosomatoida Mortensen, 1904
Family Phymosomatidae Pomel, 1883
Genus Dixieus (Cooke, 1941)

Description: Test low-arched above, rounded below. Apical system small, pentagonal, equilateral, composed of five genital plates and five ocular plates, the anterior and right anterior ocular plates nearly or quite reaching the periproct, the other ocular plates widely insert. Periproct central, comparatively large. Peristome large, circular, deeply notched, depressed. Ambulacra evenly expanded to the ambitus, where they are more than half as wide as the interambulacral areas; plates somewhat wider than high, each bearing one central, primary, crenulated, imperforate tubercle; poriferous zones above the ambitus consisting of two vertical rows of zygopores, about 12 zygopores to each compound plate, becoming somewhat disordered near the ambitus, and changing below the ambitus to one row of open, connected arcs, one arc of about six zygopores to each compound plate, breaking into two diagonal rows of three near the peristome. Interambulacral plates about as high as the ambulacral but somewhat wider, each bearing one central, imperforate, crenulated primary tubercle. Tubercles evenly graded.

Florida species: D. dixie (Cooke, 1941).

Comments: The species occurs in the Upper Ocala Limestone in north-central Florida.

Dixieus dixie (Cooke, 1941)
(Figure 3-1, F-H)

Material examined: UF 5467 (figured test), UF 66559 (figured test), UF 5342 (test), UF 5788 (test).

Description: Test moderately large, circular; upper surface gently arched; lower surface evenly rounded, concave near the peristome. Oculogenital ring monocyclic; madreporite large, tumid; other genital plates and ocular plates with sparsely scattered granules. Ambulacral areas as wide as interambulacral areas; pore pairs on upper surface biserial, nearly straight, 10 to 12 pairs on each plate, pore pairs of the two series alternating in position; pore pairs on lower surface in uniserial arcs, four or five pairs on each plate. Primary tubercles large, imperforate, crenulated, two rows on ambulacral areas and two on interambulacral areas. Miliary tubercles mammillated, near edges of plates on both ambulacral and interambulacral areas. Peristome large, circular; gill slits deeper than wide; peristomial edge of ambulacra bilobate.

Order Oligopygoida Kier, 1967
Family Oligopygidae Duncan, 1889
Genus Oligopygus de Loriol, 1887

Description: Slightly concave orally, deep depression around peristome; anterior petal usually longest, pores subequal, conjugate; apical system subcentral; periproct inframarginal; tubercles imperforate, noncrenulate.

Florida species: Three species are present, including O. wetherbyi de Loriol, 1887, O. haldemani (Conrad, 1850), and O. phelani Kier, 1967.

Comments: Species of Oligopygus are abundant in the Eocene: O. phelani, (Lower Ocala Limestone); O. haldemani and O. wetherbyi (Upper Ocala Limestone).

Oligopygus phelani Kier, 1967
(Figure 3-1, I-J)

Material examined: UF 18017 (figured test), UF 1645 (test), UF 5854 (28 tests), UF 12551 (test), UF 38222 (150 tests).

Description: Test small, elongate; width 83 to 88 percent of length, length-width ratio quite constant; in smaller specimens marginal outline oval, in large specimens subpentagonal, pointed anteriorly, blunted posteriorly with greatest width anterior; greatest height commonly at apical system, in some specimens anterior; height quite variable, ranging from 42 to 60 percent of length; adapical surface slightly convex, sides smoothly curving, adoral surface lacking deep peristomal sulcus, only depressed immediately around peristome opening. Apical system central to slightly posterior; monobasal, madreporite strongly inflated, several tubercles on madreporite; ocular plates small; four genital pores, anterior pair closer together than posterior, pores large in some specimens small in others. Petals well developed, open in some specimens, straight, slightly closing in others; interporiferous zone widest in petal III where almost twice as wide as single poriferous zone; in other petals interporiferous zone slightly wider than poriferous zone; petal III longest with four to nine more pore pairs in single poriferous zone than petals II or IV, four to seven more than petals V or I; pores strongly conjugate, in sutures between plates. Beyond petals, ambulacral plates single pored; at extremity of petal, pores very

numerous in many included ambulacral plates and demiplates; at ambitus pores most crowded in double series in each half ambulacrum with continuous column of demiplates separating primary plates from adradial suture; a few included plates inserted between primaries and demiplates; included and demiplates near adradial border, plates thin not extending through test; nearing peristome primary plates extend to adradial suture, no included plates, one demiplate for each primary; buccal pores difficult to see. Two columns in interambulacral areas except at peristome, where column terminating in single plate. Peristome slightly anterior, central, or slightly posterior, opening slightly wider than high, curved anteriorly, slightly pointed posteriorly; not deep in sulcus, test only depressed in area immediately around opening. Periproct small, slightly wider than high; located between 54 and 73 percent of the distance from center of peristome to posterior margin. Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical side; boss large, two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well preserved specimens; small secondary tubercles scattered over area between tubercles.

Oligopygus haldemani (Conrad, 1850)
(Figure 3-1, K-L)

Material examined: UF 47257 (figured test), UF 38585 (83 tests), UF 46715 (35 tests), UF 47956 (13 tests).

Description: Horizontal outline broadly ovate, nearly circular when juvenile; upper surface nearly flat in front, slightly turned down behind and sloping toward the peristome; margin broadly rounded. Apical system central, tumid, monobasal, with four genital pores. Petals short, extending little more than halfway to the margin, the anterior the longest, expanding distally and open at the tips; poriferous zones narrower than the interporiferous; pores circular, conjugate; plates narrow. Extrapetaliferous parts of ambulacra expanding to the margin; plates wider. Interambulacra thickened around the peristome internally. Peristome central, oval, deeply sunken in a transversely elongated pit whose anterior side stands nearly vertical and whose posterior side slopes less steeply and extends about halfway to the margin. Auricles erect; prongs erect, separate, far apart. Jaws present. Periproct small, circular, submarginal. Tubercles small, sunken.

<u>Oligopygus</u> <u>wetherbyi</u> de Loriol, 1887
(Figure 3-1, M-N)

Material examined: UF 17756 (figured test), UF 17770 (test), UF 40052 (18 tests), UF 40607 (21 tests), UF 47955 (three tests).

Description: Horizontal outline broadly ovate, nearly circular when young; upper surface moderately tumid; lower surface nearly flat in front, slightly turned down behind and sloping toward the peristome; margin broadly rounded. Apical system central, tumid, monobasal, with four genital pores. Petals short, extending little more than halfway to the margin, the anterior the longest, expaning distally and open at the tips; poriferous zones narrower than the interoriferous; pores circular, conjugate; plates narrow. Extrapetaliferous parts of

ambulacra expanding to the margin; plates wider. Interambulacra thickened around the peristome internally. Peristome central, oval, deeply sunken in a transversely elongate pit whose anterior side stands nearly vertical and whose posterior side slopes less steeply and extends about halfway to the margin. Auricles erect; prongs erect, separate, far apart. Jaws present. Periproct small, circular, submarginal. Tubercles small, sunken.

Family uncertain
Genus Amblypygus L. Agassiz, 1840

Description: Circular to ovate, low-arched to high subconical, flattened orally, margin tumid; ambulacra petaloid, pores conjugate, outer pore elongate, pores small adorally; apical system apparently tetrabasal; peristome sunken, subrounded to oblique; periproct large, pyriform, inframarginal; tubercles perforate, crenulate; no evidence of girdle or lantern in adult.

Florida species: A. americanus Michelin, 1858.

Comments: The species is present in the Upper Ocala Limestone

Amblypygus americanus Michelin, 1858
(Figure 3-2, A-B)

Material examined: UF 67090 (figured test), UF 648 (test), UF 5254 (test), UF 22133 (2 tests).

Description: Test large; horizontal outline circular; upper surface more or less inflated; lower surface gently rounded, concave around the peristome and less so around the periproct; margin broadly rounded. Apical system central,

with four genital pores; a large central madreporite fills in the spaces beside the much smaller genital plates; ocular plates small. Ambulacra narrow, continuous, expanded on upper side into petals with round inner pores and elongated outer pores; petals extending to margin, inner pores forming a straight line, outer sides of petals slightly arched. Peristome subtriangular, oblique, wider than long, without floscelle. Periproct on the lower surface, large longer than wide, nearer the peristome than the margin. Tubercles small, sunken; intermediate spaces and madreporite granulated.

Order Clypeasteroida A. Agassiz, 1872
Family Fibulariidae Gray, 1855
Genus Fibularia Lamarck, 1816

Description: Test ovate, inflated; periproct close to peristome; hydropores in groove; no internal supports; five large periproctal plates; buccal membrane naked; no calcareous disc in tube feet.

Florida species: F. vaughani (Twitchell, 1915).

Comments: The species is present in the Lower Ocala Limestone, and also represents a new stratigraphic record from the Upper Ocala Limestone.

Fibularia vaughani (Twitchell, 1915)
(Figure 3-3, A-B)

Material examined: UF 38211 (figured test), UF 18014 (five tests), UF 27521 (500 tests), UF 38208 (100 tests).

Description: Test very small, thick walled, elongate egg shaped in general form, elongate subelliptical to elongate subovate in marginal outline,

somewhat pointed anteriorly, about twice as long as broad. Aboral surface is high, with height equal to width, and flattened longitudinally; adoral surface also flattened somewhat along the longitudinal median area and slightly concave around the peristome. Ambulacral petals rather well defined, relatively short; petals wide open at ends; poriferous zones diverge in almost straight lines to the ends and consist of small round pores in pairs not distinctly conjugated. Peristome is relatively large, central, slightly depressed below the surface. Periproct is very small, about one-third the diameter of the peristome and very close to the peristome. Apical system anteriorly eccentric, with four medium-sized genital pores.

Family Neolaganidae Durham, 1954
Genus Neolaganum Durham, 1954

Description: Small to medium-sized; petals nearly closed, length 0.7 of radius; plates within petals in dyads and triads; four genital pores; hydropores in branching groove; periproct oral, about 0.25 distance from margin; four or five ambulacral and three or four interambulacral coronal plates per column on oral surface.

Florida species: Two total, including N. dalli (Twitchell, 1915) and N. durhami Cooke, 1959.

Comments: Both taxa are present in only one formation each. N. dalli is diagnostic of the Avon Park Formation while N. durhami is present in the Upper Ocala Limestone.

Neolaganum dalli (Twitchell, 1915)
(Figure 3-3, C-D)

Material examined: UF 104422 (figured test), UF 18385 (81 tests), UF 28184 (23 tests).

Description: Test small, subpentagonal in marginal outline. Entire form greatly depressed, subdiscoidal, the upper surface nearly parallel with the lower. Test margin notably thickened, slightly less so at the middle of the posterior end. Lower surface flat or nearly so. Apex subcentral or very slightly eccentric anteriorly, though it is but slightly higher than the margin of the test. There is no distinct concave ring on the upper surface, but the poriferous zones of the ambulacral petals are slightly depressed below the general surface. Ambulacral petals subovate in outline, broad, extending nearly two-thirds the way to the margin, rounded, blunt, and closed at the ends. Poriferous zones very wide, as wide as the interporiferous areas, slightly depressed below the general surface; inner row of pores round, outer row slit-like, pairs of pores conjugated by very narrow grooves. Interporiferous areas narrow, standing in relief by reason of the depression of the poriferous zones. The whole surface of the test, including the interporiferous areas, covered with small tubercles, set in deep scrobicules, which are larger on the adoral surface. Apical system subcentral or slightly eccentric anteriorly, coincident with the apex. Four large genital pores, of which the anterior pair are nearer together than the posterior pair. Madreporite tumid. Peristome central or subcentral in position. Periproct small, circular, about midway between the margin and the peristome.

Neolaganum durhami Cooke, 1959
(Figure 3-3, E-F)

Material examined: UF 13026 (figured test), UF 13041 (test), UF 30599 (75 tests), UF 38581 (100 tests).

Description: Horizontal outline broadly oval to subdecagonal; upper side slightly tumid at the apex, depressed sub-marginally; margin usually thick, rounded; lower side flat. Apical system nearly central; four genital pores rather far apart; hydropores in crooked grooves. Petals long, extending nearly three-fourths the radius, equal, spatulate; poriferous zones nearly as wide as the interporiferous zones, nearly closed distally, open at the apex; inner pores circular or oval, outer pores elongated; plates compound. Peristome small central, pentagonal; teeth usually preserved; five pairs of large buccal pores. Ambulacral grooves straight, extending nearly halfway to the margin. Periproct small, circular, about three-fourths the radius from the peristome. Tubercles small, sunken, numerous. Internal concentric passageways near the margin.

Genus Durhamella Kier, 1968

Description: Test small to medium in size, low, with flat adoral surface. Plates of adapical surface may or may not be tumid, with sutures depressed. The apical system has five genital pores, and the pores occur within or without the fused genital plates. The hydropore opens in one or two slits. The petals are wide near the apical system and extend approximately one-half the distance from the apical system to the margin. The pores are conjugate, but the outer pore is not in a slit, only elongated transversely. Pseudocompound plates are present in

the petals with approximately six to eight in each petal. The accessory pores occur along the transverse sutures of the ambulacral plates adapically, but adorally throughout the basicoronal and first coronal ambulacral plates. The interambulacra terminate at the apical system, with a single quadrangular plate. Adorally, the basicoronal plates have a circular to subpentagonal outline, with a single plate in each interambulacrum, double plates in each ambulacrum. The first coronal interambulacral plates are high, extending beyond the first coronal ambulacral plates. The periproct is inframarginal, and the interior supports are concentric. No food grooves are present.

Florida species: Two species are present in Florida, including D. floridana (Twitchell, 1915) and D. ocalana (Cooke, 1942).

Comments: Both species are present in the Upper Ocala Limestone.

Durhamella floridana (Twitchell, 1915)
(Figure 3-3, G-H)

Material examined: UF 3356 (figured test), UF 3358 (test), UF 48135 (two tests).

Description: Small test, almost regularly oval in marginal outline. Entire form is greatly depressed; subdiscoidal; upper surface almost parallel with the lower; the apical region slightly tumid, the tumidity involving the larger part of the petals; the region around the ends of the petals concave; the margin notably thickened, slightly more so anteriorly than posteriorly. Lower surface flat, or nearly so. Apex slightly eccentric anteriorly, at the summit of the central tumid area, which rises but very slightly above the height of the margin. Ambulacral

petals subelliptical, somewhat pointed and closed at the ends; very short, extending only about halfway to the margin, subequal in length. Poriferous zones very narrow, much narrower than the interporiferous areas, the proximal ends poorly defined, inner row of pores round, outer row slit-like, pairs of pores conjugated. Entire surface of test covered with small tubercles set in deep scrobicules, which are somewhat larger on the lower surface. Apical system slightly eccentric anteriorly, coincident with the apex. Four large genital pores, the anterior pair being set closer together than the posterior pair. Poriferous zones do not come together at their proximal ends, and the perforations of the radial plates not visible. Peristome small, slightly eccentric anteriorly, subpentagonal. Ambulacral grooves inconspicuous. Periproct small, about half the diameter of the peristome, circular, located about one-third the way from the margin to the peristome.

Durhamella ocalana (Cooke, 1942)
(Figure 3-3, I-J)

Material examined: UF 3341 (figured test), UF 38600 (100 tests), UF 65706 (14 tests).

Description: Outline subpentagonal to oval; margin thick; submargin depressed; petaloid region tumid; lower surface flat. Individual plates in the area between the thick rim and the petals tumid. Apical system slightly eccentric anteriorly; five genital pores. Petals short, extending about halfway to the margin; nearly closed; poriferous zones much narrower than interporiferous zones, widely separated at the proximal ends. Peristome very small, pentagonal,

central. Periproct about one-quarter way from the margin to the peristome. Tubercles fairly large, of uniform size; more widely scattered on the lower than on the upper surface.

Genus Weisbordella Durham, 1954

Description: Like Neolaganum but with larger periproct and without groove for hydropores; oral surface slightly concave.

Florida species: Two species are present in Florida, including Weisbordella cubae (Weisbord, 1934) and W. johnsoni (Twitchell, 1915).

Comments. Both species are present in the Upper Ocala Limestone.

Weisbordella cubae (Weisbord, 1934)
(Figure 3-3, K-L)

Material examined: UF 5846 (figured test), UF 5839 (test), UF 41280 (162 tests), UF 47164 (17 tests), UF 64432 (3 tests).

Description: Test very small, thin, subovate, longer than broad, slightly thicker at the anterior margin than at the posterior. Dorsal face somewhat conical, low, rising somewhat above the level of the margins, with a subdued ridge in the posterior interradium extending from near the disc to the margin. Peristome subcentral, perhaps a bit eccentric anteriorly. Periproct flush, subpentagonal, a short distance from the posterior margin, in the antero-posterior plane of symmetry. Apical disc slightly eccentric anteriorly. Ambulacral petals subequal, petaloid, broad at the disc, pointed and closed distally, not quite reaching the margin. Interporiferous zone moderately convex, about twice as

wide as the poriferous zone which is virtually flush, and arrayed with oblique, conjugate pore pairs, the pores of a pair not distinct but seemingly subequal. The test is ornamented with rather small, lightly scrobiculate tubercles, less numerous and fainter dorsally than ventrally. At the apex are three or four tubercles somewhat larger than average, though impressed about the same. In addition to these are four tubercles larger than any of the others and more prominently scrobiculate, two of which are in interambulacrum 2, and one each in interambulacra 3 and 4, situated near the distal ends of the petals.

Weisbordella johnsoni (Twitchell, 1915)
(Figure 3-3, M-N)

Material examined: UF 47957 (figured test), UF 5807 (test), UF 12985 (test), UF 37553 (test).

Description: Test moderate in size and almost regularly oval in marginal outline. Upper surface moderately elevated centrally; height about one-third of the width; the tumid area extending to the ends of the petals; the submarginal area about equal in thickness to the margin, which is slightly undulating, very thick, high and rounded, thicker and higher than in related forms, slightly thinner at the middle of the posterior end than elsewhere. Lower surface decidedly concave; the concavity reaching nearly to the margin and near the peristome being about equal to one-half the height of the test. Apex subcentral. Posterior petals lanceolate; the anterior three subelliptical, all of them pointed and closed at the ends, extending two-thirds or more of the way to the margin; anterior pair slightly shorter than the rest. Poriferous zones very narrow, much narrower than

the slightly tumid interporiferous areas, sometimes irregular, inner ends poorly defined, inner row of pores round, outer row slit-like, pairs of pores conjugated. Whole surface of test covered with rather conspicuous small tubercles which are larger on lower surface. Apical system subcentral, with four large genital pores. Peristome small, subpentagonal, subcentral; ambulacral grooves poorly defined. Periproct small, subcircular to subpentagonal, about one-third the way from the margin to the peristome.

Genus Wythella Durham, 1954

Description: Similar to Cubanaster but larger, margin thinner, petals raised and interambulacral areas widened midway on oral surface; also similar to Neorumphia but interambulacra much narrower at ambitus.

Florida species: W. eldridgei (Twitchell, 1915).

Comments: The species is present in the Upper Ocala Limestone.

Wythella eldridgei (Twitchell, 1915)
(Figure 3-3, O-P)

Material examined: UF 5803 (figured test), UF 39541 (46 tests), UF 46933 (25 tests), UF 48492 (11 tests).

Description: Test large, subpentagonal to subdecagonal in marginal outline, longitudinally elongate, truncated at the anterior and posterior ends, more or less undulating along the sides. Whole form greatly depressed, margin thin but thicker than slightly concave submarginal area, petaloidal region tumid. Apex and apical system subcentral. Four large genital pores are present, with the

anterior pair set closer together than the posterior pair. Whole test is closely set with very small tubercles, among which are scattered at irregular distances some larger ones in deep scrobicules. Lower surface flat. Ambulacral petals long, elongate elliptical, extending two-thirds the way to the margin, pointed and closed at the ends; pairs of pores conjugated by very narrow more or less wavy grooves. Ambulacral areas very wide at margin, narrowing rapidly to ends of petals. Peristome moderate in size, subcentral, subpentagonal to subelliptical, transversely elongate. Ambulacral grooves apparently simple and straight, each groove having a fine line on both sides which rapidly diverge from the main groove. Periproct relatively large, suboval, longitudinally elongate, one-fourth the way from the margin to the peristome.

Family Protoscutellidae Durham, 1955
Genus Protoscutella Stefanini, 1924

Description: Cooke describes the test as low, ambitus thin, usually with posterior periproctal notch; petals equal, length about half of radius; periproct submarginal, between third and fourth coronal plates; food grooves simple, nonbranched; posterior interambulacrum discontinuous; six or seven ambulacral and three to five interambulacral coronal plates on oral surface.

Florida species: P. pentagonium Cooke, 1942.

Comments: This species is problematic with respect to biostratigraphy. Cooke (1942) reported this echinoid from a water (?) well drilled in Washington County, Florida, and stated the age of the rock as middle Eocene in age, possibly representing the Lisbon Formation. I have not been able to locate the specimen

he referred to in his paper, and therefore I can only consider the formation in which the fossil is found to be uncertain.

Protoscutella pentagonium Cooke, 1942

Material examined: No UF specimens were available for examination.

Description: Test subpentagonal, tumid medially, margin thin, slightly bent down; covered with small tubercles. Apical system central; five genital pores. Petals equal in length, lanceolate, open at the ends, extending halfway to the margin; interporiferous zones about equal in width to poriferous zones; anterior petal swollen at the apical end, somewhat wider than the others. Lower surface flat except for the turning down of the margin; ambulacral furrows straight, extending almost to the margin. Peristome small, central, round. Periproct round, one-fourth the way from the margin to the peristome; connected with the margin by a shallow furrow.

Genus Periarchus Conrad, 1866

Description: Test raised apically, ambitus thin; petals open, slender, length slightly over half of radius, anterior longest; periproct oral, nearly half distance from peristome, between first pair coronal plates; food grooves bifurcate about midway on oral surface; all interambulacra continuous; usually seven ambulacral and four or five interambulacral coronal plates on oral surface.

Florida species: P. lyelli floridanus Fischer, 1951.

Comments: This species is present in the Lower Ocala Limestone.

Periarchus lyelli floridanus Fischer, 1951
(Figure 3-4, A-B)

Material examined: UF 17913 (figured test mold), UF 12795 (figured test mold), UF 1187 (test), UF 12754 (test mold), UF 45565 (two test fragments).

Description: Test large, flat, subcircular, with somewhat wavy or polygonal margin. Petaloid area slightly tumid, surrounded by a terrace from which a gently inclined bevel leads to the sharp margin. Apical system central or nearly so, apex at centrally located madreporite or at base of anterior petal. Five genital pores. Anterior petal longest, posterior petals intermediate, antero-lateral petals shortest. Longest petals reach nearly halfway to margin. Petals are broadly lanceolate, reaching maximum diameter near the midpoint. Their outer margins are more or less regular convex arcs except distally where in contact with the first pair of non-petaloid ambulacral plates; here petals are abruptly terminated by concave margins. Interporiferous zones are broadly lanceolate at proximal end, widen gently to one-half to three-quarters of their length, then taper gradually to the narrow, open, distal end. Poriferous zones begin narrow, widen for half their length, then maintain their width until near the end, where they suddenly taper to produce the concave margins. Inner pores are slightly elliptical; outer ones form long, narrow slots. Oral surface flat. Peristome small; position subcentral, variable. Periproct very small, nearer to peristome than to margin. Five actinal grooves bifurcate at angle of 30° to 35°, about halfway to margin. At margin interambulacral areas are slightly larger than the ambulacral areas. The tumid central region houses a large Aristotle's lantern; remainder of test shows a

complex internal septation. Each of the peripheral plates carries a system of septa. Inner plates carry a few low septa or ridges radiating out from peristome.

Genus Mortonella Pomel, 1883

Description: Like Periarchus but test thick, margin rounded, petals broader, and periproct midway on oral surface.

Florida species: Two taxa are present, including M. quinquefaria (Say, 1825) and M. quinquefaria kewi Cooke, 1942).

Comments: These echinoids were reported from the Crystal River Formation (Upper Ocala Limestone), although the formation they were collected from is still questionable. Cooke (1959, p. 44) stated he did not believe this genus is valid and, at best, should be a subgenus of Periarchus.

Mortonella quinquefaria (Say, 1825)
(Figure 3-5, A-B)

Material examined: UF 2202a & b (two tests figured), UF 2203 (12 tests), UF 2204 (7 tests).

Description: Horizontal outline circular; upper surface slightly tumid centrally, submargin flat; margin generally rather thick or beveled, oral side flat. Apical system central, having a large central madreporite and five genital pores. Petals wide, nearly equal in length, extending three-quarters of distance to margin, outer edges convex; poriferous zones wider than the interporiferous zones, closed at the apical ends, open distally; inner pores circular, in nearly straight lines; outer pores elongated; pores conjugate. Peristome small, circular,

central; food grooves extending halfway to margin, where the grooves bifurcate; each branch of the grooves has an outward branching extending nearly at right angles to it before curving to the margin; grooves punctate. Periproct smaller than the peristome, circular, nearly midway between the peristome and margin. Sunken tubercles cover entire surface, including the apical system.

Mortonella quinquefaria kewi (Cooke, 1942)
(Figure 3-5, C-D)

Material examined: UF 5275 (figured test).

Description: Test circular, margin weakly fluted, thin, covered with small tubercles. Apical region tumid; five genital pores at the same distance from the center as the apical ends of the petals. Petals nearly closed at the apical ends; wider open at the outer ends; interporiferous zones somewhat narrower than poriferous zones, nearly straight, widening slightly distally; inner pores round, connected by grooves with the slot-shaped outer pores; petals extending three-fifths the way to the margin. Petals encircled by a tumid ring, which gives the submarginal area a beveled appearance. Base flat; ambulacral furrows branching about halfway to the margin; buccal tubes extending to the bifurcation. Peristome nearly circular, sunken, about twice as large as the periproct. Periproct small; midway between the peristome and the margin.

Order Cassiduloida Claus, 1880
Family Echinolampadidae Gray, 1851
Genus Echinolampas Gray, 1825

Description: Medium-sized to large, usually inflated; apical system monobasal; poriferous zones usually unequal, wide interporiferous zones.

Florida species: E. tanypetalis Harper and Shaak, 1974.

Comments: This species is present in the Upper Ocala Limestone.

Echinolampas tanypetalis Harper and Shaak, 1974
(Figure 3-5, E-F)

Material examined: UF 5385 (figured test), UF 2283 (test), UF 3378 (test), UF 3900 (test).

Description: Test large, ovate to roundly subpentagonal; greatest height near center; anterior margin broadly rounded; posterior margin broadly rounded adapically, somewhat sloping adorally; adoral surface depressed around peristome. Apical system anterior of center, and approximately 44 percent of test length from anterior margin; monobasal, with four genital pores. Petals very long, extending almost to margin, broad, with interporiferous zones greater than four times width of poriferous zones; pores conjugate, nearly perpendicular to petal axis, outer pores transversely elongated, inner pores round; poriferous zones of unequal length, more pore pairs in right zone of petal III, posterior zones of petals II and IV, and outer zones of petals I and V; petals I, III, and V straight, petals II and IV flexed slightly toward anterior; petals with no tendency to close distally. Periproct inframarginal, transverse, large roundly triangular. Peristome anterior of center, distance from anterior margin approximately 42 percent of test

length; transverse, large, roundly triangular to subpentagonal. Bourrelets poorly developed; phyllodes well developed, narrowing toward peristome, single-pored with many pores arranged in two series in each half ambulacrum: in ambulacrum III, two series in each half, with eight pores in outer series, three to four in inner series; in others, eight pores in outer series, four to six in inner series; buccal pores present. Tubercles small, somewhat depressed, more numerous and smaller on adoral surface.

Family Cassidulidae L. Agassiz and Desor, 1847
Genus Rhyncholampas A. Agassiz, 1869

Description: Small to large, oral surface flat; apical system monobasal or tetrabasal; periproct supramarginal to marginal, longitudinal or transverse; peristome transverse; petals broad, usually equal, commonly inconspicuous, ambulacral plates double-pored in pre-Senonian species; tubercles much larger adorally, naked zone in interambulacrum 5 adorally.

Florida species: A total of six taxa (two of which being subspecies) are present in Florida, including R. conradi (Conrad, 1850), R. conradi lyelli (Conrad, 1850), R. ericsoni (Fischer, 1951), R. georgiensis (Twitchell, 1915), R. georgiensis globosus (Fischer, 1951), and R. trojanus (Cooke, 1942).

Comments: The taxa in this genus are present throughout the Ocala Limestone, with R. conradi, R. conradi lyelli, and R. trojanus preserved in the Upper Ocala Limestone and R. ericsoni, R. georgiensis, and R. georgiensis globosus part of the Lower Ocala Limestone.

Rhyncholampas conradi (Conrad, 1850)
(Figure 3-6, A-C)

Material examined: UF 39452 (figured test), UF 39453 (13 tests), UF 64904 (9 tests), UF 65809 (16 tests).

Description: Horizontal outline oval, usually somewhat compressed posterolaterally; upper surface evenly tumid, rostrate above the periproct; lower surface usually slightly concave around the peristome; margin broadly rounded. Apical system anteriorly eccentric, monobasal, with four genital pores. Petals long and rather straight, open distally; inner poriferous zones of paired petals longer than the outer; inner pores circular, outer pores oval. Peristome large, pentagonal, wider than long, nearer the center than the apical system; phyllodes nearly as wide as long; bourrelets elongated, swollen, granulated. Periproct terminal, at the top of a narrow vertical truncation, wider than high. Tubercles depressed, small on upper surface, larger on lower; covering entire test except a narrow pitted band behind the peristome.

Rhyncholampas conradi lyelli (Conrad, 1850)
(Figure 3-6, D-F)

Material examined: UF 3343 (figured test), UF 3350 (2 tests), UF 47100 (2 tests), UF 48502 (2 tests).

Description: This variety is more nearly oval than typical R. conradi, lacking the posterolateral constriction that gives R. conradi a pointed appearance. It is proportionately somewhat longer and narrower than R. conradi carolinensis.

Rhyncholampas ericsoni (Fischer, 1951)
(Figured 3-6, G-I)

Material examined: UF 37661 (figured test), UF 38223 (7 tests), UF 41270 (8 tests), UF 46635 (test).

Description: Test outline subpentagonal-subhexagonal, spatulate, wider behind than in front. Aboral surface a rather high, inflated cone, uniformly covered with small scrobicules. Apex at or just forward of the apical system, which is decidedly eccentric toward the anterior. Behind the apex a gentle rostrum leads to the upper margin of the periproct. Below the periproct a broad, shallow sulcus extends to the margin. Along the sides of the test the inflated aboral surface overhangs the sharp margins. Oral surface comparatively flat, most prominent at sides, slightly concave around peristome, rises markedly toward posterior margin. Three specimens show a slight anterior sulcus. Peristome directly below apical system, slightly wider than long, surrounded by a large floscelle with prominent bourrelets. Oral surface covered with large, deep scrobicules except on anterior and posterior median bands, which are finely granulate. Posterior band inflated. Periproct at about half the total height, transversely elongate, upper margin gently arched, lower margin more or less eccentrically angular. Apical system with four genital pores and central madreporite. Petals lanceolate, open distally, nearly equal in length. Interporiferous zones in mid-portion two to three times as wide as poriferous zones. On posterior petals the anterior pore rows are longer than the posterior rows. Pores conjugate; inner ones almost circular, outer ones tapering inward.

Ridges between pore pairs carry one to three scrobiculate tubercles. The number of pores in a row varies from around 40 to 46.

Rhyncholampas georgiensis (Twitchell, 1915)
(Figure 3-6, J-K)

Material examined: UF 22535 (figured test), UF 12744 (3 tests).

Description: Test broadly oval in marginal outline, more obtusely rounded posteriorly than anteriorly, and obliquely truncated at the posterior end. Upper surface is regularly convex, moderately elevated, in the form of a low, rounded ridge above the periproct, sides and anterior end rounded and inflated; adoral surface flat, curving upward slightly posteriorly to meet the oblique posterior truncation in an angular margin, the angle formed being about 75°. Apex is subcentral. Ambulacral areas are narrow, dorsal portions petaloid, the petals narrow, partly open at the ends, the posterior petals longer than the others, which are nearly equal in length. Poriferous zones are narrow; the inner zone of each of the posterior pair of petals shorter than the outer zone; outer row of pores slit-like, inner row round; pairs of pores conjugate. Aboral surface of the test is closely set with numerous small tubercles which increase in size on the adoral surface except along a rather wide median band which is free from tubercles and dotted with numerous small pits. Tubercles are set in scrobicules that are shallow and irregularly shaped on the aboral surface; but become larger, deeper and more regular in form on the adoral surface. Apical system is eccentric anteriorly, with four genital pores, of which the anterior pair are nearer together than the posterior, and five small perforated radial plates. Peristome is

eccentric anteriorly, immediately beneath the apical system, pentagonal, transversely elongate, with a floscelle of which the phyllodes are rather well defined and the bourrelets are large and prominent. Periproct is relatively small, about 3 or 4 mm in length, subelliptical to subrhomboidal, transverse; and located relatively high up on the posterior surface, at the top of the rather high posterior truncation, beneath a rounded, transverse, somewhat protruding expansion of the test.

Rhyncholampas georgiensis globosus (Fischer, 1951)
(Figure 3-6, L-O)

Material examined: UF 32945 (figured test), UF 36435 (figured test), UF 3342 (2 tests), UF 28182 (5 tests), UF 39094 (test).

Description: Test medium to large for genus, highly inflated, outline nearly circular, profile four-fifths to nearly as high as long. Oral surface moderately convex, joining sides at an ill-defined, rounded edge of spatulate outline; widest in posterior third. Peristome and apex anteriorly eccentric. Peristome pentagonal, transversely elongate, with narrow, beaded bourrelets. Periproct at half height, its arched upper margin projecting, lower margin forming a broad “V” shape. Test gently rostrate above periproct; a flat band with faint median ridge leads from periproct to margin. Sides of test faintly divided into similar vertical facets. The sides of the test overhang the oral wall on all sides, but much more so in front than in the rear, to produce a forward-leaning appearance. Top and sides of test covered with small scrobicules. On the margins of the oral side these grade into large scrobicules which cover the latter except on

the anterior and posterior longitudinal median bands, which are finely beaded. Apical system with four large genital and five small ocular pores and central madreporite. Petals slender, lanceolate, wide open at the ends. On each antero-lateral petal the posterior row of pores is longer than the anterior row, whereas on each of the posterior petals the anterior row of pores is longer than the posterior row. Inner pores round to slightly elliptical; outer pores slightly ovoid.

Rhyncholampas trojanus (Cooke, 1942)
(Figure 3-6, P-Q)

Material examined: UF 3747 (figured test), UF 41273 (test), UF 45915 (test), UF 48497 (12 tests).

Description: Outline subquadrate, wider posterior than at anterior. Upper surface moderately inflated except behind the periproct, where there is a broad, shallow sulcus; rostrate above the periproct. Lower surface flat. Margin acute. Apical system slightly eccentric anteriorly; four genital pores, five ocular pores, madreporite central. Petals lanceolate, of nearly equal length, extending somewhat more than halfway to the margin, open at the distal ends; pores round or oval; interporiferous zones wider than poriferous zones; outer poriferous zones of posterior paired petals longer than the inner. Peristome farther forward than the apical system, pentagonal, slightly wider than long. Oral lobes swollen. Phyllodes about as long as the diameter of the peristomial opening. Periproct supramarginal, transversely elliptical, flush, about one-third the way from the margin to the apex. Upper surface finely granulated between small tubercles; tubercles on lower surface much larger than on upper, deeply sunken in large

scrobiculae except near the margin, where they are much smaller. Longitudinal median band on base moderately wide and deeply pitted.

Family Pliolampadidae Kier, 1962
Genus Eurhodia Haime, 1853

Description: Medium to large, elongate, low to moderately inflated; adorally flattened, apical system monobasal; petals equal, broad, closing distally, ambulacral plates beyond petals single pored; periproct supramarginal, transverse or longitudinal; peristome higher than wide; bourrelets strongly developed; phyllodes broad, single pored, with two series of pores in each half-ambulacrum; buccal pores present; tubercles perforate, considerably larger adorally than adapically, except for naked and often pitted adoral interambulacrum 5.

Florida species: E. patelliformis (Bouvé, 1851).

Comments: The species is present in the Upper Ocala Limestone.

Eurhodia patelliformis (Bouvé, 1851)
(Figure 3-7, A-B)

Material examined: UF 4932 (figured test), UF 3321 (3 tests), UF 41265 (test), UF 47103 (2 tests), UF 47959 (test).

Description: Oblong-ovate, and rather pointed posteriorly; horizontal outline semicircular in front, narrowly truncated behind. Superior face concavo-convex, and forming with the inferior an acute margin. Apical system slightly anterior, directly above the periproct, monobasal, four genital pores. Ambulacral

areas narrow; petals lanceolate, closed at apex, open distally, the anterior pair somewhat shorter than the others; poriferous zones of nearly equal length, somewhat narrower than the interporiferous; inner pores circular, outer pores oval or elongate. Peristome pentagonal, slightly longer than wide; bourrelets strong, bulbous. Periproct supramarginal, nearly circular, opening into a shallow sulcus, which indents the margin and continues forward into the periproct, forming an internal shelf or tube. Upper surface and margin covered with small sunken tubercles; tubercles on lower surface much larger, sunken in deep pits; posterior interambulacrum on lower surface without tubercles but deeply pitted; similar pits surround the anterior phyllode. Test width-length ratio approximately 0.7 and height-length ratio approximately 0.45.

Order Spatangoida Claus, 1876
Family Hemiasteridae Clark, 1917
Genus Ditremaster Munier-Chalmas, 1885

Description: Subglobular, with faint frontal sinus; two gonopores; paired ambulacra petaloid, posterior pair very short, about 0.3 length of anterior ones.

Florida species: D. beckeri (Cooke, 1942).

Comments: The species is present in the Upper Ocala Limestone.

Ditremaster beckeri (Cooke, 1942)
(Figure 3-7, C-D)

Material examined: UF 47040 (figured test), UF 4922 (2 tests), UF 5819 (test), UF 41274 (test).

Description: Test tumid above and below, margin rounded, highest behind the center, sloping steeply forward, vertically truncated behind. Apical system behind the center, with two posterior genital pores. Anterior ambulacral area deeply depressed halfway to the margin, then becoming shallower, but depression still perceptible at the peristome. Petals deeply depressed; anterior pair long, with nearly straight margins, slightly curved outwards at the tip; posterior pair depressed, much shorter; interporiferous zones about as wide as poriferous zones; pores elongate oval, conjugate. Peristome fairly large, curved, with a strongly rostrate posterior lip; near the anterior end. Periproct oval, higher than wide, high up on the posterior end. Peripetalous fasciole deeply indented between the lateral petals.

Family Schizasteridae Lambert, 1905
Genus Schizaster L. Agassiz, 1836

Description: Test high, sloping anteriorly from posterior vertex, beaked over periproct; ambulacra sunken, frontal one deeply depressed; posterior petals 0.3 to 0.5 as long as anterior pair; apical system ethmolytic with two to four gonopores.

Florida species: Two described species are reported from Florida, including S. armiger (Clark, 1915) and S. ocalanus Cooke, 1942, and one Schizaster sp. is yet to be formally described.

Comments: All three taxa of Schizaster are present in the Upper Ocala Limestone.

Schizaster armiger (Clark, 1915)
(Figure 3-7, E-F)

Material examined: UF 3302 (figured test), UF 4942 (test), UF 5558 (14 tests), UF 45568 (3 tests).

Description: Test moderately large, much depressed and cordiform in marginal outline. Upper surface slopes at first rapidly from a sharp anterior margin to near the apical system, where it becomes nearly flat for a short distance. Beyond the apical system a sharp elevated ridge highest near the middle point continuous on to the truncated posterior margin. Ambulacra are broad, the single anterior ambulacrum being situated in a deep broad groove that deeply indents the anterior margin. Paired ambulacra have broad deep petals, the anterolateral being somewhat over one and a half times as long as the posterolateral. Interambulacra are more or less flat, slightly gibbous, the posterior much elevated forming a sharp ridge. The surface is thickly covered with small perforate tubercles. The peripetalous and lateral fascioles are very distinct. The peristome is near the anterior margin in a shallow depression. The periproct is high on truncated posterior margin.

Schizaster ocalanus Cooke, 1942
(Figure 3-7, G-H)

Material examined: UF 5833 (figured test), UF 5864 (test), UF 41268 (test), UF 45567 (test), UF 64439 (test).

Description: Test subglobular, cordate, the anterior depression extending from the apical system to the peristome, the upper surface more

inflated than the lower. Apical system nearly central, with two large genital pores, one between the ends of each lateral pair of petals, and the madreporite extending behind them. Anterior ambulacral area moderately sunken; pores of each pair separated by a high granule. Petals nearly straight, sunken; anterior pair diverging at an angle of approximately 120°, the posterior at an angle of approximately 60°; anterior pair about twice as long as posterior; open at the distal ends; poriferous zones about as wide as interporiferous zones; pores conjugate. Peripetalous fasciole concave between the lateral petals, convex elsewhere. Peristome far forward, subtrigonal to subpentagonal, strongly lipped posteriorly, weakly lobate anterolaterally. Periproct about as large as the peristome, elliptical, higher than wide, high up on the flattened, sloping posterior end. Surface covered with small tubercles.

<u>Schizaster</u> sp.
(Figure 3-7, I-K)

Material examined: UF 68927 (figured test), UF 68926 (figured test).

Formation: Upper Ocala Limestone.

Locality: Steinhatchee Pits (DI005); Dixie County, FL; Clara Quadrangle, Sec. 15/21/22/28, T8S, R10E; Hunter bed 3.

Collector: M. Hunter.

Date: Unknown.

Description: Test small to medium size; horizontal outline subcircular to subpentagonal. Aboral surface inflated, broadly curving; highest point in posterior third of test along medial ridge traversing from apical system to

posterior margin. Apical system located near test center; petaloid ambulacra depressed, with ambulacrum III producing modest sulcus at anterior margin; anterior petals (II and IV) diverge at slightly less than 90° from each other as do posterior pair (I and V); anterior petals relatively straight, longer than posterior petals; terminate approximately half the distance to test margin; posterior petals short, extending less than half of distance to margin. Test margin broadly rounded at ambitus, but abrupt and flattened at posterior margin. Periproct small, elliptical with long axis vertical; located inframarginal just below aboral surface. Adoral surface slightly convex; peristome located in anterior third, small, transversely elliptical with modest labrum. Tubercles larger near margin, smaller adapically; fascioles distinct.

Comments: Two described species, S. ocalanus and S. armiger, are known from the Upper Ocala Limestone and are available for comparison with this fossil. The specimen described herein appears to differ somewhat from both of these taxa and may represent a new species. Unfortunately, the described fossil is not perfectly preserved, particularly in the apical system and much of the aboral surface, thereby limiting complete description and analysis of the morphological features. Recognizing these limitations, several comments are provided regarding possible specific identification based on the unidentified specimen. The peristome of S. ocalanus is very near the anterior margin, and proportionally closer than observed in the Schizaster sp. fossil. The unidentified specimen also is more strongly carinate in posterior of aboral surface as compared with S. ocalanus.

Comparison with S. armiger shows differences between the fossils as well. The unidentified Schizaster sp. has less depressed petaloid ambulacra than S. armiger, and the relative length of the petals is shorter than S. armiger. Therefore, I interpret this fossil to be a new and undescribed species of Schizaster from the Eocene, and count this as a new taxonomic record, a unique species for the Eocene diversity count, and as a new stratigraphic record for Florida. A caution should be made, however, that the specimen is not perfectly preserved and more specimens must be collected to thoroughly differentiate and define the morphological features present on this echinoid fossil.

Genus Agassizia L. Agassiz and Desor, 1847

Description: Egg-shaped, with ethmolytic apical system showing four gonopores and fused genital plates; frontal ambulacrum flush, petals slightly sunken and curiously modified; in anterior petals anterior plate row bearing tiny tube feet which emerge through microscopic pores, whereas pores of posterior plate row are normally developed; posterior petals much shorter and may be normal or similarly modified.

Florida species: Two species are reported from Florida. One species is A. clevei Cotteau, 1875, and the second is A. sp. cf. A. wilmingtonica Cooke, 1942.

Comments: A. clevei is present in the Lower Ocala Limestone, while A. sp. cf. A. wilmingtonica is present in the Upper Ocala Limestone.

Agassizia clevei Cotteau, 1875
(Figure 3-7, L-M)

Material examined. UF 5841 (figured test), UF 38221 (118 tests), UF 39091 (3 tests), UF 45918 (test).

Description: Horizontal outline obovate, truncated behind; upper surface strongly inflated, highest in front of the genital system; margin broadly rounded; lower surface gently convex. Apical system behind the center; four genital pores, close together; ethmolytic, madreporite extending between the ocular plates. Anterior ambulacrum very slightly depressed. Paired petals straight, slightly depressed; anterior pair twice as long as the posterior; both pairs diverging at an angle of approximately 90°; pores of posterior petals and posterior zone of anterior paired petals small, pores very minute; interporiferous zones narrow. Peristome at the anterior third, large, reniform, weakly lipped. Periproct transversely oval, about midway up the posterior end, at the top of a truncation. Marginal fasciole curving downward below the periproct; hemipetalous fasciole meeting the marginal fasciole behind the anterior paired petals.

Agassizia sp. cf. A. wilmingtonica Cooke, 1942
(Figure 3-7, N-O)

Material examined: UF 68931 (figured; one incomplete test).

Formation: Upper Ocala Limestone.

Locality: Steinhatchee Pits (DI005); Dixie County, FL; Clara Quadrangle, Sec. 15/21/22/28, T8S, R10E.

Collector: M. Hunter.

Date: Unknown.

Description: Horizontal outline suboval to subcircular; aboral surface inflated, becoming less rounded in apical region; test margin broadly curved; adoral surface slightly convex, with longitudinal crest along plastron to posterior peristome labrum. Apical system positioned in slight depression, slightly anterior of test center; four genital pores. Anterior petals (II and IV) diverge at approximately 105°, while posterior pair (I and V) diverge at approximately 80°; petals shallowly depressed, with ambulacrum III least developed and sunken; pore pairs not visible on specimen, but general petal shape relatively narrow and elongate. Periproct and posterior margin broken and absent. Peristome arcuate, about two to three times as wide as long; located in anterior third of test; elevated and prominent posterior labrum. Tubercles small, densely distributed throughout test surfaces.

Comments: This fossil is an important addition to the Eocene echinoid record of the state. Although the specimen has undergone recrystallization and fragmentation, it is easy to identify the genus as <u>Agassizia</u>. Comparison with described species within this genus tends to support my interpretation that matches most closely (though not perfectly) with <u>A</u>. <u>wilmingtonica</u> Cooke, 1942. This interpretation is supported by similar petaloid ambulacra dimensions and orientations, as well as the peristome shape and position found in the above specimen and <u>A</u>. <u>wilmingtonica</u>. However, since the newly reported fossil from Dixie County is incomplete, I have chosen to refer to the specimen as <u>Agassizia</u> sp. cf. <u>A</u>. <u>wilmingtonica</u> until additional specimens are collected that show all the

morphological features necessary to confirm this interpretation. With respect to biostratigraphy data, the fossil is a new stratigraphic record for the Upper Ocala Limestone and is counted as a unique species for the Eocene diversity total, but it is not considered to be a new taxonomic record.

Family Brissidae Gray, 1855
Genus Brissiosis L. Agassiz in Agassiz and Desor, 1847

Description: Ovate, somewhat depressed, with slight frontal sinus; ethmolytic, two to four gonopores; ambulacra slightly depressed; paired ones petaloid, may have rudimentary pores in proximal plates; petals confluent in some species; subanal fasciole may be lost in adults.

Florida species: Two species present, including B. steinhatchee Cooke, 1942 and a second, undescribed taxon referred to as Brissopsis sp. reported herein.

Comments: Both species are present in the Upper Ocala Limestone.

Brissopsis steinhatchee Cooke, 1942
(Figure 3-7, P-Q)

Material examined: UF 2144 (figured test), UF 4939 (4 tests), UF 4945 (5 tests), UF 48127 (2 tests), UF 48501 (test).

Description: Horizontal outline suboval, emarginate in front, truncate behind; upper surface moderately flat, sloping gently forward, with depressed petals and anterior ambulacrum; margin broadly rounded; lower surface gently convex, somewhat rostrate behind. Apical system near the anterior third;

ethmolytic; four genital pores. Petals sunken, extending about halfway to the margin; anterior pair straight, diverging at an angle of approximately 130º; posterior pair longer, curving outward to an angle of approximately 40º; both sunken in a single depression; pores elongate-oval; interporiferous zones nearly as wide as the poriferous; inner poriferous zones narrowing and becoming obsolete near apex. Peristome curved, with rounded ends and a posterior lip. Periproct large, vertical, higher than wide.

<u>Brissopsis</u> sp.
(Figure 3-8, A-B)

Material examined: UF 68935 (test figured).

Formation: Upper Ocala Limestone.

Locality: Crystal River Rock Company A (CI016); Citrus County, FL; Homosassa Quadrangle, Sec. 6, T19S, R18E.

Collector: M. Hunter.

Date: Unknown.

Description: Horizontal outline elongate, ellipsoid; upper surface moderately inflated; test margin broadly rounded; adoral surface slightly convex, with minimally carinated posterior region. Posterior margin truncated; periproct located inframarginally on truncation (covered with matrix). Test partially covered with secondary calcite crystals and cemented matrix. Ambulacra sunken; pore pairs not readily visible; anterior petals longer than posterior petals, extending to near margin; posterior petal extending approximately half the distance to margin; petals relative straight. Apical system (covered, not directly visible) estimated to

lie slightly anterior of test center. Periproct and peristome covered as well. Tubercles generally small, with larger ones located on plastron.

Comments: This fossil is somewhat difficult to identify with confidence as a result of the matrix strongly cemented to the test surface and the recrystallization of test plates. The only species of Brissopsis from the Eocene of Florida is B. steinhatchee (see earlier description). This fossil does not match the characteristics of B. steinhatchee in two important morphological features. First, the ambulacral petal length of this newly reported fossil posses anterior petals that are significantly longer than the posterior petals, whereas the opposite is true for B. steinhatchee. The second difference is in the relative position of the apical system, such that B. steinhatchee has its apical system in the anterior third of the test whereas in this fossil it is located only slightly anterior of center. Due to these differences, I have chosen to refer to this fossil as Brissopsis sp. herein and consider it to be a potential new taxonomic record, a new stratigraphic record for the Upper Ocala Limestone, and I include it as a unique species for the Eocene echinoid diversity total.

Genus Eupatagus L. Agassiz, 1847

Description: Test ovoid in outline, low, oral side flat; apical system anterior, ethmolytic, with four gonopores; paired ambulacra with closed petals; frontal ambulacrum non-petaloid, pores in single series, phyllodes weak; primary tubercles on aboral side only within peripetalous fasciole.

Florida species: Four species of Eupatagus are present, including E. antillarum (Cotteau, 1875), E. clevei (Cotteau, 1875), E. ocalanus Cooke, 1942, and one species tentatively identified as Eupatagus cf. ocalanus.

Comments: Two species, E. antillarum and E. clevei, are present in the Lower Ocala Limestone and one or two species (E. ocalanus and Eupatagus sp. cf. E. ocalanus) are found in the Upper Ocala Limestone.

Eupatagus antillarum (Cotteau, 1875)
(Figure 3-8, C-D)

Material examined: UF 3913 (figured test), UF 46462 (test), UF 49989 (test), UF 55191 (5 tests).

Description: Horizontal outline obovate, truncated behind; upper surface moderately elevated, highest midway between the apical system and the periproct, sloping gently forward; lower surface flat; margin rounded. Apical system slightly eccentric forward, ethmolytic, the madreporite protruding far behind the ocular plates; four genital pores close together. Anterior ambulacrum narrow, not petaloid, slightly flattened, plates nearly equilateral. Petals long, extending nearly to the margin, slightly flexuous; anterior pair diverging at an angle of approximately 145°, posterior pair 40°; pores circular, strongly conjugate; poriferous zones nearly closed, narrow. Peristome at the anterior third, rounded somewhat wider than long; labrum not conspicuously projecting. Floscelle conspicuous. All interambulacra reaching the peristome. Periproct terminal, vertical, higher than wide, about mid-height, at the top of a small truncation. Peripetalous fasciole not indented; subanal fasciole heart shaped.

Large tubercles arranged in parallel zigzag rows in the four lateral interambulacra, confined within the peripetalous fasciole. Smaller tubercles closely cover the interambulacra on the lower side. Tubercles arranged in radiating rows on the escutcheon, forming a pattern suggestive of a pair of spread wings. Lower parts of ambulacra smooth and appearing callused.

Eupatagus clevei (Cotteau, 1875)
(Figure 3-8, E-F and Figure 3-9, A-B)

Material examined: UF 12681 (figured test), UF 12903 (figured test), UF 35808 (test), UF 35809 (test), UF 35824 (test), UF 35825 (test).

Description: Test large, hemispherical; horizontal outline oval; upper surface strongly inflated, slightly flattened in front; lower surface nearly flat; margin very broadly rounded. Apical system slightly anterior, small; four genital pores; ethmolytic, the madreporite protruding far behind the ocular plates. Anterior ambulacrum narrow, plates nearly equilateral, pore pairs very small. Petals long, extending to the margin, very wide, flush, lanceolate, ore or less open distally; pores oval, conjugate; poriferous zones narrow, much narrower than the interporiferous zones; paired ambulacra much expanded at the ends of the petals. Peristome at the anterior third, reniform, twice as wide as long, strongly lipped; floscelle conspicuous. Plates of the trivium almost excluding the interambulacral plates at the peristome. Periproct terminal, vertical, higher than wide. Peripetalous fasciole narrow, not indented. Subanal fasciole apparently heart shaped. Tubercles rather small, scrobiculate.

Eupatagus ocalanus Cooke, 1942
(Figure 3-9, C-D)

Material examined: UF 46942 (figured test), UF 3335 (test), UF 4364 (7 tests), UF 47043 (6 tests), UF 48489 (6 tests).

Description: Test large, oval, truncated behind; upper surface rostrate above the periproct, sloping to the rounded margin; lower surface nearly flat but projecting downward where the subanal fasciole crosses the median line. Apical system slightly in front of the center; four genital pores, close together; madreporite extending behind the posterior pair of ocular pores. Anterior ambulacral area not at all petaloid, flattened. Petals slightly depressed; anterior pair extending four-fifths the way to the margin, diverging at an angle of 135°; posterior pair longer, extending three-fourths the way to the margin, diverging at an angle of 47°. Poriferous zones about as wide as interporiferous zones; pores elliptical, conjugate. Peristome large, elliptical, labiate behind, slightly farther forward than the apical system. Periproct large, terminal, supramarginal, pear-shaped. Peripetalous fasciole without indentations but having a V-shaped projection above the periproct. Subanal fasciole heart-shaped, enclosing a spread-wings-shaped escutcheon studded with large tubercles arranged in transverse lines. Sternum covered with somewhat smaller tubercles. Posterior ambulacral areas almost smooth on lower surface. Paired interambulacral areas on lower surface covered with a coarse reticulation of large tubercles. Large tubercles on upper surface confined within the peripetalous fasciole, arranged in zigzag rows in the posterior paired interambulacral areas, fewer and more scattered in the other interambulacral areas.

Eupatagus sp. cf. E. ocalanus Cooke, 1942
(Figure 3-10, A-B)

Material examined: UF 68936 (figured test).

Formation: Upper Ocala Limestone.

Locality: Crystal River Rock Company A (CI016); Citrus County, FL; Homosassa Quadrangle, Sec. 6, T19S, R18E.

Collector: M. Hunter.

Date: Unknown.

Description: Horizontal outline suboval, narrowing posteriorly while broadly curving along anterior margin. Aboral surface moderately inflated; highest point anterior of apical system; margins broadly curving; adoral surface nearly flat to slightly convex. Apical system eccentric anteriorly (not visible on specimen); ambulacra straight, with consistent width and rounded terminus. Periproct absent due to compaction and crushing. Peristome moderate in size; slightly wider than long; anterior edge curved, posterior edge broken; located approximately midway between center and anterior margin; posterior labrum apparently elevated and prominent. Tubercles not visible due to recrystallization.

Comments: The specimen is in a relatively poor preservation state, thereby limiting the description and identification. The specimen can be identified as the genus Eupatagus, but the species cannot be determined at this time. A comparison with the species E. antillarum (Lower Ocala Limestone) does not match with respect to general test shape, and the same is true for E. clevei (Lower Ocala Limestone), which is also a significantly larger echinoid. One other species, E. ocalanus, is present in the Upper Ocala Limestone. The fossil

described here matches at least moderately well with E. ocalanus based on general test shape and peristome position. Therefore, I refer to this fossil as Eupatagus sp. cf. E. ocalanus to convey the uncertainty associated with the poor preservation. The specimen is not considered a new stratigraphic record or a new taxonomic record, and using the assumption that it may be another fossil of E. ocalanus, it is not counted as a unique species for the Eocene echinoid diversity total.

Genus Macropneustes L. Agassiz, 1847

Description: Differs from Eupatagus chiefly in having depressed petals, and broad test; frontal sinus distinct.

Florida species: M. mortoni (Conrad, 1850).

Comments: This species is present in the Upper Ocala Limestone.

Macropneustes mortoni (Conrad, 1850)
(Figure 3-10, C-D)

Material examined: UF 3309 (figured test), UF 12976 (test), UF 12986 (test), UF 38000 (test).

Description: Test thin. Horizontal outline broadly oval, flattened or very slightly emarginate in front. Upper surface swollen, evenly rounded. Margin broadly rounded. Lower surface flattish, depressed around the peristome. Apical system at the anterior third; four genital pores, close together; ethmolytic, the madreporite extending far behind the ocular plates. Anterior ambulacrum not petaloid, slightly depressed, plainly depressed near the peristome. Petals flush

or slightly depressed, straight, long, extending nearly to the margin, open distally; inner pores circular, outer pores oval, pores conjugate; interporiferous zones equal in width to the poriferous zones, not expanding medially. Peristome lunate, with a prominent posterior lip; at the anterior third. Periproct large, broadly oval, erect, higher than wide, about mid-height, at the top of a slight depression. Peripetalous fasciole narrow, circular in front, straight or offset behind, zigzag on the sides. Subanal fasciole broadly U-shaped. Large tubercles crenulate, perforated, not confined within the fascioles.

Genus Plagiobrissus Pomel, 1883

Description: Differs from Eupatagus chiefly in having anal branches on subanal fasciole, long plastron, short labrum, and long, narrow, flexed petals.

Florida species: Two species are present, including P. curvus (Cooke, 1942) and Plagiobrissus? dixie (Cooke, 1942).

Comments: P. curvus occurs in both the lower and upper members of the Ocala Limestone. Fossils of Plagiobrissus? dixie are present only in the Upper Ocala Limestone. Cooke (1959, p.87) noted the question regarding the true generic status of this species is a reflection of both morphology and preservation. He questioned the referral of this fossil to Plagiobrissus because it lacks an anal fasciole (which is diagnostic of the genus), yet agreed with its removal from Eupatagus due to the narrowness of the ambulacra and the length of the plastron. Further complication of this question results from the poor preservation of the holotype, which is an internal mold.

Plagiobrissus curvus (Cooke, 1942)
(Figure 3-11, A)

Material examined: UF 17243 (figured test), UF 4365 (5 tests), UF 4889 (test), UF 4966 (test), UF 48496 (test).

Description: Test ovate, low, margin rounded. Anterior ambulacral area not at all petaloid, slightly depressed. Anterior pair of petals nearly as long as the posterior pair, widely diverging, extending more than two-thirds the way to the margin, constricted near the tips; interporiferous zones as wide as poriferous zones at the tips, twice as wide elsewhere; poriferous zones convex near the apex, straighter near the tip. Posterior petals curved slightly backward, diverging at an angle of 30°, extending less than two-thirds the way to the margin; outer poriferous zones convex, inner nearly straight; interporiferous zones little wider than poriferous zones in medial part, equal near the ends. Pores conjugate. Peristome oval, labiate behind, farther forward than the apical system. Periproct terminal, above the margin, pear-shaped. Peripetalous fasciole without lateral sinuations, slightly bent backward at the anterior end and more strongly bent backward at the posterior end. Subanal fasciole heart-shaped, enclosing a spread-wings-shaped escutcheon, which is studded with large tubercles arranged in transverse lines and perforated by at least six pores on each side. All four paired interambulacral areas studded with large tubercles within the peripetalous fasciole; nearly bare elsewhere on upper surface; studded with large, evenly spaced tubercles on lower surface. Plastron resembling fish scales.

Plagiobrissus? dixie (Cooke, 1942)
(Figure 3-11, B-C)

Material examined: UF 4929 (figured test), UF 4937 (7 tests), UF 4958 (test), UF 4969 (test), UF 5808 (2 tests).

Description: Test oval, depressed, truncate behind, margin rounded, upper surface little more inflated than the lower, rostrate above the periproct. Apical system in front of the center; four genital pores close together, the posterior pair separated by the elongated madreporite. Anterior ambulacral area not at all petaloid nor depressed. Petals somewhat sunken; anterior pair curved slightly forward, diverging at an angle of about 145°, extending about three-fourths of the way to the margin, shorter than the posterior pair; posterior petals straight, diverging at an angle of nearly 50°, extending nearly two-thirds of the way to the margin; poriferous zones wider than interporiferous zones; pores conjugate. Peristome large, wider than long, evenly curved in front, labiate behind. Periproct about as large as the peristome, pear-shaped, above the margin, on the steeply truncated end. Peripetalous fasciole without marked indentations. Subanal fasciole, heart-shaped, enclosing a spread-wings-shaped escutcheon covered with large tubercles; remainder of lower posterior interambulacral area covered by closer, smaller tubercles. Ambulacral areas on lower surface bare. Paired interambulacral areas on lower surface covered by lines of large tubercles. Upper surface well covered by small tubercles; large tubercles confined within the peripetalous fasciole, most abundant between and adjacent to the paired petals.

Figure 3-1. Eocene regular and irregular echinoids.

A) Phyllacanthus mortoni (Conrad, 1850); UF 66913; aboral view of test; Ocala Limestone; 1x.

B) Phyllacanthus mortoni (Conrad, 1850); UF 66913; adoral view of test; Ocala Limestone; 1x.

C) Phyllacanthus mortoni (Conrad, 1850); UF 66913; lateral view of test; Ocala Limestone; 1x.

D) DIADEMATOIDA; UF 32929; hemi-pyramid of lantern; Ocala Limestone; 1x.

E) DIADEMATOIDA; UF 32929; hemi-pyramid of lantern; Ocala Limestone; 1x.

F) Dixieus dixie (Cooke, 1941); UF 5467; aboral view of test; Ocala Limestone; 1x.

G) Dixieus dixie (Cooke, 1941); UF 5467; adoral view of test; Ocala Limestone; 1x.

H) Dixieus dixie (Cooke, 1941); UF 66559; aboral view of partial test with intact lantern; Ocala Limestone; 1x.

I) Oligopygus phelani Kier, 1967; UF 18017; aboral view of test; Ocala Limestone; 1x.

J) Oligopygus phelani Kier, 1967; UF 18017; adoral view of test; Ocala Limestone; 1x.

K) Oligopygus haldemani (Conrad, 1850); UF 47257; aboral view of test; Ocala Limestone; 1x.

L) Oligopygus haldemani (Conrad, 1850); UF 47257; adoral view of test; Ocala Limestone; 1x.

M) Oligopygus wetherbyi de Loriol, 1887; UF 17756; aboral view of test; Ocala Limestone; 1x.

N) Oligopygus wetherbyi de Loriol, 1887; UF 17756; adoral view of test; Ocala Limestone; 1x.

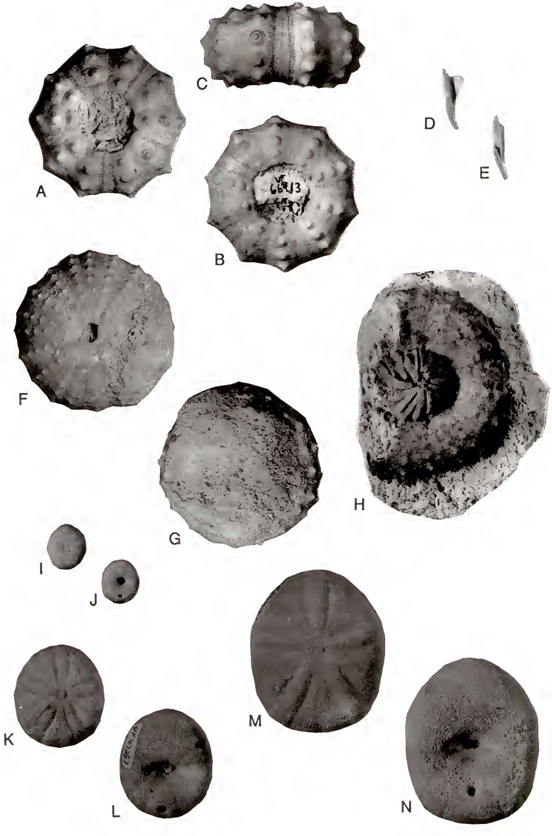
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Figure 3-2. Eocene irregular echinoids.

A) Amblypygus americanus Michelin, 1858; UF 67090; aboral view of test; Ocala Limestone; 1x.

B) Amblypygus americanus Michelin, 1858; UF 67090; adoral view of test; Ocala Limestone; 1x.

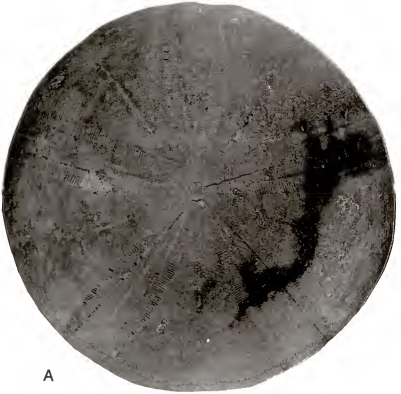

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Figure 3-3. Eocene irregular echinoids.
A) Fibularia vaughani (Twitchell, 1915); UF 38211; aboral view of test; Ocala Limestone; 2x.
B) Fibularia vaughani (Twitchell, 1915); UF 38211; adoral view of test; Ocala Limestone; 2x.
C) Neolaganum dalli (Twitchell, 1915); UF 104422; aboral view of test; Avon Park Formation; 1x.
D) Neolaganum dalli (Twitchell, 1915); UF 104422; adoral view of test; Avon Park Formation; 1x.
E) Neolaganum durhami Cooke, 1959; UF 13026; aboral view of test; Ocala Limestone; 1x.
F) Neolaganum durhami Cooke, 1959; UF 13026; adoral view of test; Ocala Limestone; 1x.
G) Durhamella floridana (Twitchell, 1915); UF 3356; aboral view of test; Ocala Limestone; 1x.
H) Durhamella floridana (Twitchell, 1915); UF 3356; adoral view of test; Ocala Limestone; 1x.
I) Durhamella ocalana (Cooke, 1942); UF 3341; aboral view of test; Ocala Limestone; 1x.
J) Durhamella ocalana (Cooke, 1942); UF 3341; adoral view of test; Ocala Limestone; 1x.
K) Weisbordella cubae (Weisbord, 1934); UF 5846; aboral view of test; Ocala Limestone; 1x.
L) Weisbordella cubae (Weisbord, 1934); UF 5846; adoral view of test; Ocala Limestone; 1x.
M) Weisbordella johnsoni (Twitchell, 1915); UF 47957; aboral view of test; Ocala Limestone; 1x.
N) Weisbordella johnsoni (Twitchell, 1915); UF 47957; adoral view of test; Ocala Limestone; 1x.
O) Wythella eldridgei (Twitchell, 1915); UF 5803; aboral view of test; Ocala Limestone; 1x.
P) Wythella eldridgei (Twitchell, 1915); UF 5803; adoral view of test; Ocala Limestone; 1x.


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Figure 3-4. Eocene irregular echinoids.

A) Periarchus lyelli floridanus Fischer, 1951; UF 17913; aboral view of dolomitized, partial internal mold of test; Ocala Limestone; 1x.

B) Periarchus lyelli floridanus Fischer, 1951; UF 12795; adoral view of dolomitized, partial internal mold of test; Ocala Limestone; 1x.


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VF 17913
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Figure 3-5. Eocene irregular echinoids.

A) *Mortonella quinquefaria* (Say, 1825); UF 2202a; aboral view of test; Ocala Limestone; 1x.

B) *Mortonella quinquefaria* (Say, 1825); UF 2202b; adoral view of test; Ocala Limestone; 1x.

C) *Mortonella quinquefaria kewi* (Cooke, 1942); UF 5275; aboral view of test; Ocala Limestone; 1x.

D) *Mortonella quinquefaria kewi* (Cooke, 1942); UF 5275; adoral view of test; Ocala Limestone; 1x.

E) *Echinolampas tanypetalis* Harper and Shaak, 1974; UF 5385; aboral view of partial test; Ocala Limestone; 1x.

F) *Echinolampas tanypetalis* Harper and Shaak, 1974; UF 5385; adoral view of partial test; Ocala Limestone; 1x.

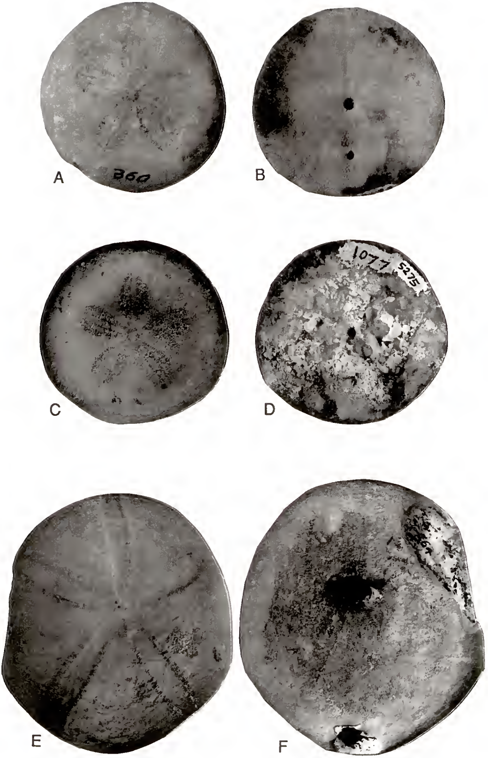
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Figure 3-6. Eocene irregular echinoids.

A) Rhyncholampas conradi (Conrad, 1850); UF 39452; aboral view of test; Ocala Limestone; 1x.
B) Rhyncholampas conradi (Conrad, 1850); UF 39452; adoral view of test; Ocala Limestone; 1x.
C) Rhyncholampas conradi (Conrad, 1850); UF 39452; lateral view of test; Ocala Limestone; 1x.
D) Rhyncholampas conradi lyelli (Conrad, 1850); UF 3343; aboral view of test; Ocala Limestone; 1x.
E) Rhyncholampas conradi lyelli (Conrad, 1850); UF 3343; adoral view of test; Ocala Limestone; 1x.
F) Rhyncholampas conradi lyelli (Conrad, 1850); UF 3343; lateral view of test; Ocala Limestone; 1x.
G) Rhyncholampas ericsoni (Fischer, 1951); UF 37661; aboral view of test; Ocala Limestone; 1x.
H) Rhyncholampas ericsoni (Fischer, 1951); UF 37661; adoral view of test; Ocala Limestone; 1x.
I) Rhyncholampas ericsoni (Fischer, 1951); UF 37661; lateral view of test; Ocala Limestone; 1x.
J) Rhyncholampas georgiensis (Twitchell, 1915); UF 22535; aboral view of dolomitized internal mold of test; Ocala Limestone; 1x.
K) Rhyncholampas georgiensis (Twitchell, 1915); UF 22535; adoral view of dolomitized internal mold of test; Ocala Limestone; 1x.
L) Rhyncholampas georgiensis globosus (Fischer, 1951); UF 32945; aboral view of dolomitized internal mold of test; Ocala Limestone; 1x.
M) Rhyncholampas georgiensis globosus (Fischer, 1951); UF 36435; aboral view of dolomitized internal mold of test; Ocala Limestone; 1x.
N) Rhyncholampas georgiensis globosus (Fischer, 1951); UF 36435; adoral view of dolomitized internal mold of test; Ocala Limestone; 1x.
O) Rhyncholampas georgiensis globosus (Fischer, 1951); UF 36435; lateral view of dolomitized internal mold of test; Ocala Limestone; 1x.
P) Rhyncholampas trojanus (Cooke, 1942); UF 3747; aboral view of test; Ocala Limestone; 1x.
Q) Rhyncholampas trojanus (Cooke, 1942); UF 3747; adoral view of test; Ocala Limestone; 1x.

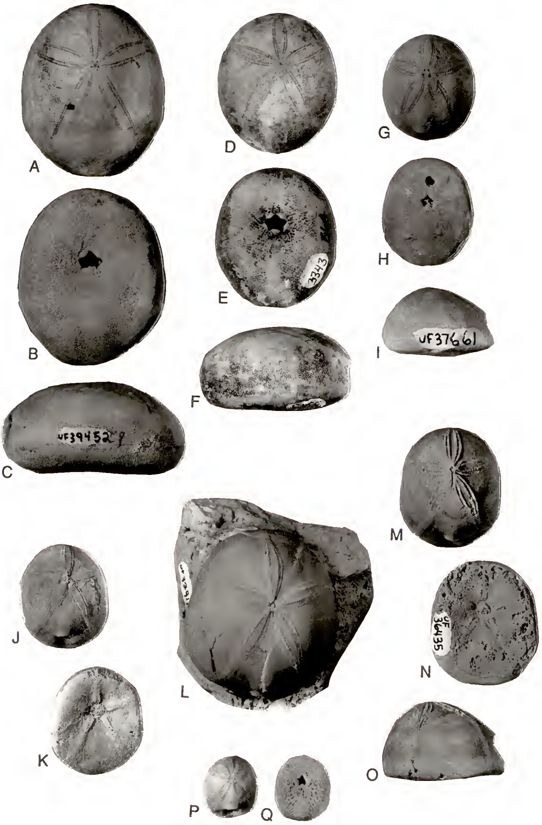
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Figure 3-7. Eocene irregular echinoids.

A) Eurhodia patelliformis (Bouvé, 1851); UF 4932; aboral view of test; Ocala Limestone; 1x.
B) Eurhodia patelliformis (Bouvé, 1851); UF 4932; adoral view of test; Ocala Limestone; 1x.
C) Ditremaster beckeri (Cooke, 1942); UF 47040; aboral view of test; Ocala Limestone; 1x.
D) Ditremaster beckeri (Cooke, 1942); UF 47040; adoral view of test; Ocala Limestone; 1x.
E) Schizaster armiger (Clark, 1915); UF 3302; aboral view of test; Ocala Limestone; 1x.
F) Schizaster armiger (Clark, 1915); UF 3302; adoral view of test; Ocala Limestone; 1x.
G) Schizaster ocalanus Cooke, 1942; UF 5833; aboral view of test; Ocala Limestone; 1x.
H) Schizaster ocalanus Cooke, 1942; UF 5833; adoral view of test; Ocala Limestone; 1x.
I) Schizaster sp.; UF 68927; aboral view of test; Ocala Limestone; 1x.
J) Schizaster sp.; UF 68927; adoral view of test; Ocala Limestone; 1x.
K) Schizaster sp.; UF 68926; aboral view of test; Ocala Limestone; 1x.
L) Agassizia clevei Cotteau, 1875; UF 5841; aboral view of test; Ocala Limestone; 1x.
M) Agassizia clevei Cotteau, 1875; UF 5841; adoral view of test; Ocala Limestone; 1x.
N) Agassizia sp. cf. A. wilmingtonica Cook, 1942; UF 68931; aboral view of partial test; Ocala Limestone; 1x.
O) Agassizia sp. cf. A. wilmingtonica Cook, 1942; UF 68931; adoral view of partial test; Ocala Limestone; 1x.
P) Brissopsis steinhatchee Cooke, 1942; UF 2144; aboral view of test; Ocala Limestone; 1x.
Q) Brissopsis steinhatchee Cooke, 1942; UF 2144; adoral view of test; Ocala Limestone; 1x.

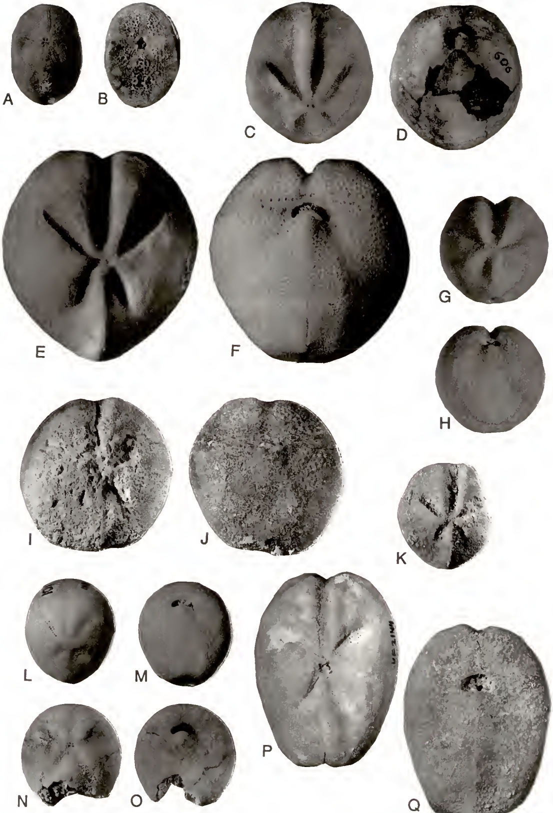
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Figure 3-8. Eocene irregular echinoids.

A) Brissopsis sp.; UF 68935; aboral view of partial test; Ocala Limestone; 1x.

B) Brissopsis sp.; UF 68935; adoral view of partial test; Ocala Limestone; 1x.

C) Eupatagus antillarum (Cotteau, 1875); UF 3913; aboral view of test; Ocala Limestone; 1x.

D) Eupatagus antillarum (Cotteau, 1875); UF 3913; adoral view of test; Ocala Limestone; 1x.

E) Eupatagus clevei (Cotteau, 1875); UF 12681; aboral view of dolomitized internal mold of test; Ocala Limestone; 1x.

F) Eupatagus clevei (Cotteau, 1875); UF 12681; adoral view of dolomitized internal mold of test; Ocala Limestone; 1x.

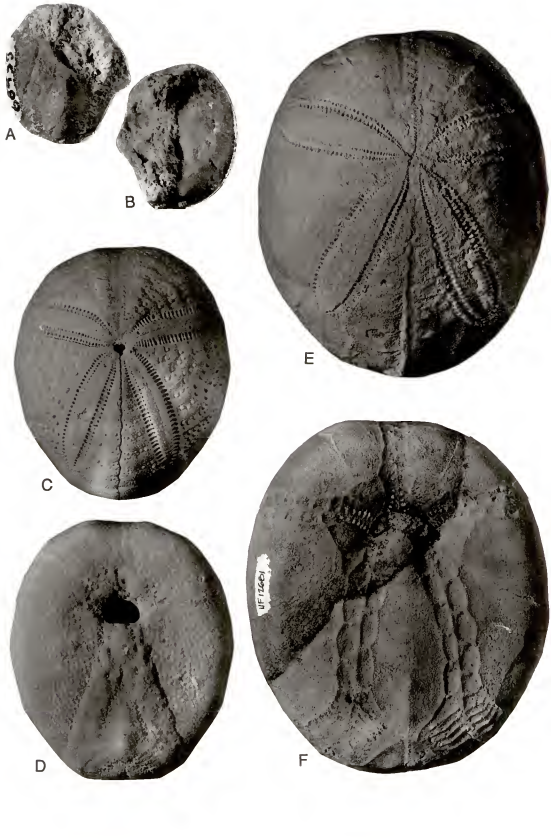
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Figure 3-9. Eocene irregular echinoids.

A) Eupatagus clevei (Cotteau, 1875); UF 12903; aboral view of test; Ocala Limestone; 1x.

B) Eupatagus clevei (Cotteau, 1875); UF 12903; adoral view of test; Ocala Limestone; 1x.

C) Eupatagus ocalanus Cooke, 1942; UF 46942; aboral view of test; Ocala Limestone; 1x.

D) Eupatagus ocalanus Cooke, 1942; UF 46942; adoral view of test; Ocala Limestone; 1x.


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Figure 3-10. Eocene irregular echinoids.

A) *Eupatagus* sp. cf. *E. ocalanus* Cooke, 1942; UF 68936; aboral view of limestone encrusted test; Ocala Limestone; 1x.

B) *Eupatagus* sp. cf. *E. ocalanus* Cooke, 1942; UF 68936; adoral view of limestone encrusted test; Ocala Limestone; 1x.

C) *Macropneustes mortoni* (Conrad, 1850); UF 3309; aboral view of test; Ocala Limestone; 1x.

D) *Macropneustes mortoni* (Conrad, 1850); UF 3309; adoral view of test; Ocala Limestone; 1x.

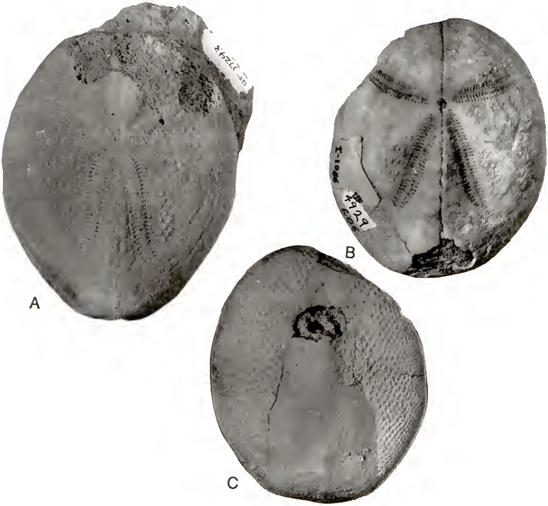

A
B
C
D

Figure 3-11. Eocene irregular echinoids.

A) *Plagiobrissus curvus* (Cooke, 1942); UF 17243; aboral view of dolomitized internal mold of test; Ocala Limestone; 1x.

B) *Plagiobrissus*? *dixie* (Cooke, 1942); UF 4929; aboral view of partial test; Ocala Limestone; 1x.

C) *Plagiobrissus*? *dixie* (Cooke, 1942); UF 4929; adoral view of partial test; Ocala Limestone; 1x.


A
B
C

Oligocene Echinoids

Order Phymosomatoida Mortensen, 1904
Family Stomechinidae Pomel, 1883
Genus Phymotaxis Lambert and Thiéry, 1914

Description: Test low hemispherical, medium-sized. Ambulacra polyporous, pore pairs in double series adorally, in single undulating line adapically. Primary tubercles in two regular series in each area.

Florida species: P. mansfieldi Cooke, 1941 and Phymotaxis sp.

Comments: Both species are present in the Suwannee Limestone. The unidentified species has been examined by several echinoid workers in addition to me, and the consensus interpretation is that it is not P. mansfieldi. The fossil awaits further detailed examination and description, but I have included this in both the new stratigraphic and taxonomic records categories.

Phymotaxis mansfieldi Cooke, 1941
(Figure 3-12, A-B)

Material examined: UF3344 (figured test), UF 3325 (test).

Description: Test large, nearly circular; upper surface somewhat depressed; lower surface evenly rounded, concave near the peristome. Ambulacral areas little more than half as wide as interambulacral areas; pores on upper surface and on ambitus arranged in connected arcs, six to eight pairs on each plate; pore pairs crowded on lower surface. Tubercles large, imperforate; two rows on each ambulacral area, four rows on each interambulacral area at the ambitus, the lateral rows dwindling and disappearing away from the ambitus; each primary tubercle surrounded by a line of small tubercles that generally

follow the edges of the plates, being somewhat larger than the others. Peristome small, subdecagonal; gill slits about as deep as wide, callous.

Phymotaxis sp.
(Figure 3-12, C)

Material examined: UF13047 (figured test).

Formation: Suwannee Limestone.

Locality: Alachua County, FL; Gainesville East Quadrangle, SE1/4, T10S, R19E.

Collector: R. Portell.

Date: 3/4/81.

Description: Horizontal outline circular; test large, subhemispherical, with evenly rounded margin; low in profile. Petaloid ambulacra convergent at apical system and peristome; maximum width at ambitus; zygopores close, rounded; ambulacra approximately two-thirds as wide as interambulacra. Two rows of prominent spines in both ambulacral and interambulacra zones; only scrobicular ring showing secondary spines. Apical system not visible due to recrystallization and replacement. Peristome large, circular, approximately one-half test diameter.

Comments: This fossil is moderately well-preserved, but degraded from its original state via silicification and recrystallization of the calcite as well as dissolution of portions of the test. Slight compaction likely also altered the specimen from its original form. However, it is identifiable to the generic level and I refer to this specimen as Phymotaxis sp. Comparison with the previously

documented species, P. mansfieldi Cooke, 1941 (see description in this section) reveals differences between the fossils. One such difference is the peristome diameter. The diameter in P. mansfieldi is relatively small in contrast with that of this unidentified species. The general shape of the test is taller in P. mansfieldi whereas Phymotaxis sp. is lower with a shield-like shape. The limited detail preserved in this fossil prevents a more thorough comparison with other described species, but based on what is observed, it is likely this fossil is a new species of Phymotaxis. Therefore, I include it as a new stratigraphic record for the Suwannee Limestone, a new taxonomic record, and include it in the total echinoid diversity value for the Oligocene of Florida.

Order Temnopleuroida Mortensen, 1942
Family uncertain
Genus Gagaria Duncan, 1889

Description: Moderate-sized, low hemispherical. Angular pores and pits lacking. No distinct sculpture on test. Tubercles crenulate, not indented, forming regular series in both areas. Apical system with only ocular I insert.

Florida species: G. mossomi (Cooke, 1941).

Comments: The species is present in the Suwannee Limestone. Specimens consist of tests, fragments, and spines in varying states of preservation.

Gagaria mossomi (Cooke, 1941)
(Figure 3-12, D-E)

Material examined: UF 28245 (figured test), UF 32350 (3 tests), UF 32401 (2 tests), UF 32531 (6 tests).

Description: Test rather small, subhemispherical, upper surface slightly flattened, lower surface rounded below the ambitus and slightly concave around the large notched peristome. Ambulacral areas narrower than interambulacral areas. Ambulacral pores large; pairs uniserial, nearly straight, but each group of three pores slightly curved around a large tubercle; each pore pair divided by a raised septum. Interporiferous areas provided with two rows, about 20 in each row, of moderately strong, crenulated, imperforate primary tubercles and two shorter rows of smaller tubercles. Interambulacra provided with two rows, about 16 in each row, of primary tubercles about equal in size to those on the ambulacra and with several rows of smaller tubercles, which are most numerous on the ambitus.

Order Clypeasteroida A. Agassiz, 1872
Family Clypeasteridae L. Agassiz, 1835
Genus Clypeaster Lamarck, 1801

Description: Medium-sized to large, test flattened to highly campanulate, margin rounded to flattened and inflated; peristome usually in deep infundibulum; oral surface flat to concave; petals variable, closed and rounded to open or sublyrate, with outer pores elongate, inner ones rounded, commonly connected by groove; periproct usually inframarginal, rarely marginal, situated between third and fourth, or fourth and fifth pair of coronal plates; buccal membrane naked, with imbedded irregular spicules; internal supports variable in abundance, consisting of thin laminae and pillars; wall of test sometimes double, separated by pillars. Variation in external test morphology and shape of petals is very

great, more than 400 nominal taxa existing in the literature, but no systematic basis for subgeneric groupings can be recognized.

Florida species: Four species are present, including C. batheri Lambert 1915, C. cotteaui Egozcue, 1897, C. oxybaphon Jackson, 1922, and C. rogersi (Morton, 1834).

Comments: All four species are present in the Suwannee Limestone. In addition to their presence the Suwannee Limestone, C. cotteaui is preserved in the Bridgeboro Limestone while C. rogersi is found in the Marianna Limestone. The fossils of C. batheri reported herein represent a new stratigraphic occurrence of this species in the Suwannee Limestone.

Clypeaster batheri Lambert, 1915
(Figure 3-12, F-G)

Material examined: UF 2546 (figured test), UF 5341 (test).

Description: Test medium size, longer than wide, depressed, oval, narrowed anteriorly, subtruncated posteriorly. Upper surface moderately convex, ventrally widely and deeply concave. Petals wide open, with a tendency to narrow toward the extremities.

Clypeaster cotteaui Egozcue, 1897
(Figure 3-12, H-I)

Material examined: UF 54993 (figured test), UF 54996 (test), UF 54997 (test), UF 54998 (test fragment), UF 54999 (test fragment), UF 67416 (test).

Description: Test moderate size, oval, narrowed anteriorly, upper surface slightly convex. Margin thick and rounded. Lower surface concave, with ambulacral furrows which expand and deepen approaching peristome. Peristome pentagonal. Periproct circular, slightly separated from the margin. Apex nearly central, only slightly eccentric anteriorly. Apical disk small, with madreporite constituting a relatively large star. Ambulacral areas superficial, petals truncate and very open at the distal tips. Poriferous areas slightly depressed and very characteristic, the inner series of pores curving and converging near the apex of each ambulacrum, below making a straight line to distal tips, but converging. Outer series of pores curve throughout entire length, forming in the extreme tip a curve of less radius, converging to meet the inner series; as a sort of termination, four pores, smaller and elongated, form an irregular quadrilateral. Each poriferous plate with six tubercles.

Clypeaster oxybaphon Jackson, 1922
(Figure 3-13, A-B)

Material examined: UF 4926 (figured test).

Description: Test low, pentagonal in outline, elongate anteriorly, truncate posteriorly; thick and rounded on the margin, depressed in a dish-like fashion dorsally, and in the center of the dish the proximal portion of the petals with the apical disk rise in a slight eminence, moderately concave ventrally. Ambulacral petals slightly raised above the general surface of the test; petals gently rounded, but open at the distal tips. Poriferous areas are sunken; pores are connected by well-marked furrows, the ridges between poriferous areas present a gentle curve

from the base to the distal end. Petals I, V, and III are closely of the same length and width; II and IV are shorter, but of about the same width as the others. The apical disk is central in position, genital pores are large and sunken. Periproct well removed from the posterior border of the test. Ambulacral grooves are strongly marked, deepening toward the centrally placed mouth. Tubercles are small, closely associated, and somewhat larger and more crowded on the ventral side.

<u>Clypeaster</u> <u>rogersi</u> (Morton, 1834)
(Figure 3-13, C-D)

Material examined: UF 3314 (figured test), UF 65819 (7 tests), UF 65820 (6 tests), UF 68932 (test).

Description: Test outline oval to subpentagonal; upper surface low to tumid apically; lower surface relatively flat, slightly concave near the peristome; margin usually thin. Apical system central, tumid, with five gonopores. Petals extending more than halfway to the margin, completely closed apically, wide open distally; poriferous zones somewhat narrower than the interporiferous, inner pores circular, outer pores slightly elongated, pores weakly conjugate; inner side of poriferous zones almost straight, outer side slightly convex. Peristome central, pentagonal, sides slightly swollen, like bourrelets. Ambulacral grooves straight, narrow, extending to the margin. Periproct circular, located about one-fifth the distance from the margin to the peristome. Tubercles on upper surface small, sunken; tubercles on lower surface larger, in much larger scrobicules; intermediate spaces pitted.

Order Cassiduloida Claus, 1880
Family Cassidulidae L. Agassiz and Desor, 1847
Genus Rhyncholampas A. Agassiz, 1869

Description: See Eocene echinoid section for generic description.

Florida species: R. gouldii (Bouvé, 1846).

Comments: This species is present in the Suwannee Limestone and represents a relatively abundant and pervasive macrofossil in the formation. The biostratigraphic value of this species is strong because of the clear and unquestioned association with most facies of this Oligocene limestone unit.

Rhyncholampas gouldii (Bouvé, 1846)
(Figure 3-13, E-F)

Material examined: UF 67813 (figured test), UF 36608 (test), UF 46464 (6 tests), UF 46632 (6 tests), UF 66562 (test).

Description: Aboral test surface conico-convex, more sloping posteriorly than anteriorly. Margin somewhat rounded except near and under anus, where by a depression it becomes acute. Adoral surface subcircular; peristome located about one-third the distance from anterior margin. Apex subcentral, slightly anterior, though not as far as peristome. Ambulacra radiating at unequal angles, the interambulacral spaces dividing the three anterior from the two posterior being wider than the rest. Ambulacral pores in pore pairs diverge considerably from the apex, becoming quite dilated a short distance from apical system, then converging as they descend, until about two-thirds the distance from the peak to the margin; pores then change from double rows to single; at margin pores again dilate, and are traceable to termination at peristome where distinctly prominent.

Anterior ambulacrum much narrower than rest. Periproct transverse, situated about one-fifth the distance from posterior margin to apex.

Order Spatangoida Claus, 1876
Family Schizasteridae Lambert, 1905
Genus Schizaster L. Agassiz, 1836

Description: See Eocene echinoid section for generic description.

Florida species: S. americanus Clark, 1915.

Comments: This species is present in two formations (possibly three with the Bridgeboro Limestone), including the Suwannee Limestone and the Marianna Limestone. Its presence in both of the formations reported herein thereby reflects two new stratigraphic records for this species in Florida.

Schizaster americanus Clark, 1915
(Figure 3-13, G-H)

Material examined: UF 55006 (figured test), UF 5276 (2 tests), UF 27345 (test).

Description: Test of medium size, rather tall, subpentagonal, as wide as long, sloping up from the anterior margin to the nearly central apical system, beyond which a sharp rise continues toward the posterior margin, its highest point being about midway. Ambulacra narrow; the anterior one situated in a deep, moderately wide groove that indents the anterior margin. Paired ambulacra with deep short petals, the anterolateral being about twice as long as the posterolateral. Interambulacra are broad and somewhat gibbous on the sides; posterior interambulacrum is much elevated and rather narrow. Test

surface covered with numerous small, but clearly distinct tubercles with small granules between them. The peripetalous and lateral fasciole can be readily traced. Apical system small, nearly central in position. Peristome near anterior margin in a well-marked depression. Periproct high on truncated posterior margin.

Genus Agassizia L. Agassiz and Desor, 1847

Description: See Eocene echinoid section for generic description.

Florida species: A. mossomi Cooke, 1942.

Comments: This species is present in the Suwannee Limestone.

Agassizia mossomi Cooke, 1942
(Figure 3-13, I-J)

Material examined: UF 55007 (figured test), UF 3316 (2 tests), UF 27143 (tests), UF 27183 (7 tests), UF 27187 (4 tests).

Description: Test nearly spherical, less tumid beneath, truncated behind. Apical system nearly central, with four genital pores, the posterior pair separated by an elongated madreporite, which extends behind them. Petals forming a nearly right-angled X; more deeply sunken than customary for the genus; front pair half again as long as the back pair; pores of anterior zone of front pair small and oblique distally, very minute near the apex; interporiferous zones of back pair narrower than the poriferous zones. Anterior ambulacral area slightly sunken near the apex, flush at the margin. Peristome semilunate, with a posterior lip, located at the anterior third. Periproct large, transversely oval, terminal, at the

top of the truncation. Marginal fasciole forming a V-shape below the periproct, joined by the hemipetalous fasciole behind the anterior pair of petals. Interambulacral areas covered with close-set tubercles.

Family Brissidae Gray, 1855
Genus Brissopsis L. Agassiz in Agassiz and Desor, 1847

Description: See Eocene echinoid section for generic description.

Florida species: Brissopsis sp.

Comments: This species is present in the Suwannee Limestone, represented by only two specimens. My tentative interpretation is that they likely represent a new species, but further detailed examination and collection of additional specimens may be required to formally describe these fossils. However, I do include these samples in my taxonomic list and I believe they represent both new taxonomic and new stratigraphic records for the Suwannee Limestone.

Brissopsis sp.
(Figure 3-13, K-L)

Material examined: UF 9195 (figured test), UF 10719 (figured test).

Formation: Suwannee Limestone.

Locality: Hernando Beach 01 (HE001); Hernando County, FL; Aripeka Quadrangle, NE1/4, Sec. 24, T23S, R16E.

Collectors: R. Portell (UF 9195) and J. Pendergraft (UF 10719).

Date: 2/8/87 and 4/16/87, respectively.

Description: Both specimens still embedded in matrix, thereby limiting

observation. Test small; aboral surface hemispherical with peak at apical system; small tubercles apparent but poorly preserved. Apical system small; four gonopores; petaloid ambulacra sunken; petals diverging, interpolated to be at nearly right angles.

Comments: The small area of test exposed above matrix in both fossils along with recrystallization of the calcite plates and fractured regions prevents specific identification. The general test shape visible, sunken ambulacra, and four gonopores allows the tentative identification as Brissopsis sp. This preliminary identification is tenuous, however, since no other Brissopsis species have been reported from the Oligocene of Florida or neighboring states. The first record of Brissopsis from the Eocene of Florida also is part of this study, and thus comparison materials are not available in the Florida Museum of Natural History or other repositories. One record of Brissopsis in the Caribbean region is a report of an Oligocene species, B. aguayoi Sanchez Roig, 1952, from Cuba. Therefore, it is not unreasonable to expect the genus to be present in Florida strata as well. I include this fossil as a new stratigraphic record for the Suwannee Limestone, and assume the identification to valid at the generic level, thereby also permitting an interpretation of this fossil as a new taxonomic record.

Figure 3-12. Oligocene regular and irregular echinoids.

A) Phymotaxis mansfieldi Cooke, 1941; UF 3344; lateral view of test; Suwannee Limestone; 1x.

B) Phymotaxis mansfieldi Cooke, 1941; UF 3344; adoral view of test; Suwannee Limestone; 1x.

C) Phymotaxis sp.; UF 13047; aboral view of silicified test; Suwannee Limestone; 1x.

D) Gagaria mossomi (Cooke, 1941); UF 28245; aboral view of test; Suwannee Limestone; 1x.

E) Gagaria mossomi (Cooke, 1941); UF 28245; adoral view of test; Suwannee Limestone; 1x.

F) Clypeaster batheri Lambert, 1915; UF 2546; aboral view of test; Suwannee Limestone; 0.75x.

G) Clypeaster batheri Lambert, 1915; UF 2546; adoral view of test; Suwannee Limestone; 0.75x.

H) Clypeaster cotteaui Egozcue, 1897; UF 54993; aboral view of test; Bridgeboro Limestone; 1x.

I) Clypeaster cotteaui Egozcue, 1897; UF 54993; adoral view of test; Bridgeboro Limestone; 1x.

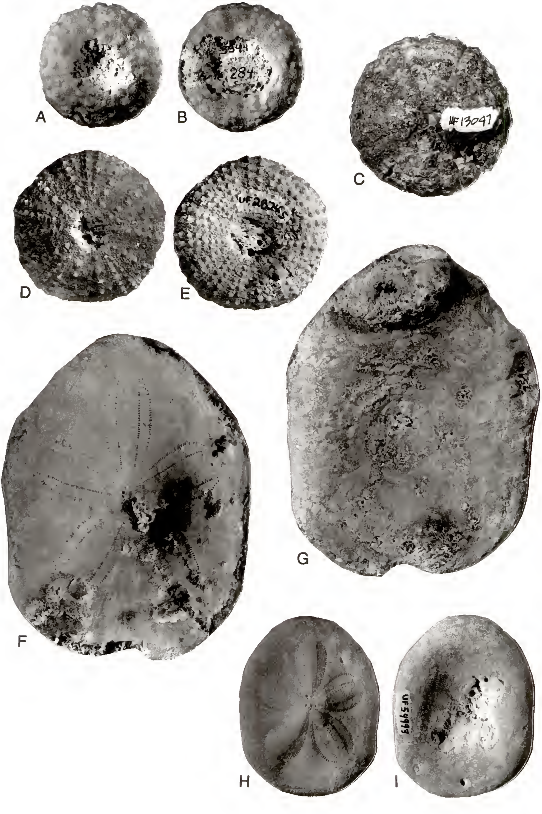

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Figure 3-13. Oligocene irregular echinoids.

A) Clypeaster oxybaphon Jackson, 1922; UF 4926; aboral view of partial test; Suwannee Limestone; 1x.

B) Clypeaster oxybaphon Jackson, 1922; UF 4926; adoral view of partial test; Suwannee Limestone; 1x.

C) Clypeaster rogersi (Morton, 1834); UF 3314; aboral view of test; Suwannee Limestone; 1x.

D) Clypeaster rogersi (Morton, 1834); UF 3314; adoral view of test; Suwannee Limestone; 1x.

E) Rhyncholampas gouldii (Bouvé, 1846); UF 67813; aboral view of test; Suwannee Limestone; 1x.

F) Rhyncholampas gouldii (Bouvé, 1846); UF 67813; adoral view of test; Suwannee Limestone; 1x.

G) Schizaster americanus Clark, 1915; UF 55006; aboral view of test; Bridgeboro Limestone; 1x.

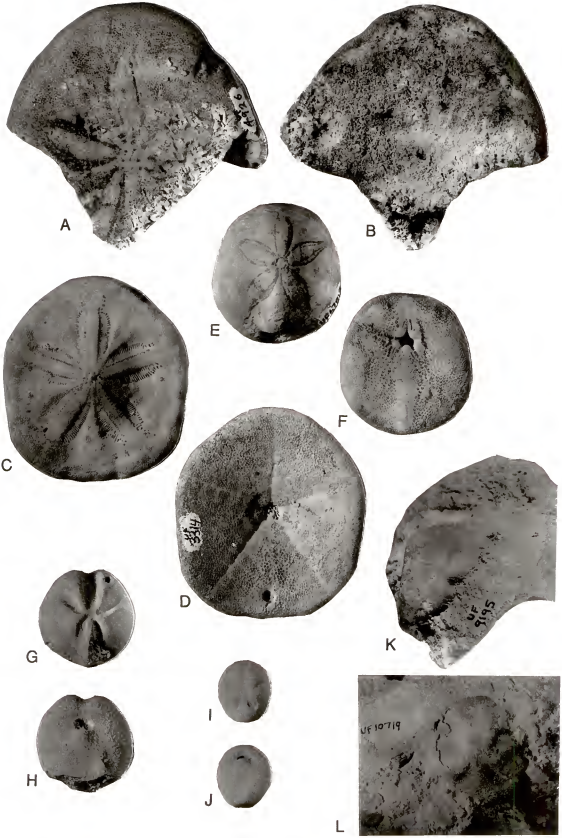
H) Schizaster americanus Clark, 1915; UF 55006; adoral view of test; Bridgeboro Limestone; 1x.

I) Agassizia mossomi Cooke, 1942; UF 55007; aboral view of test; Suwannee Limestone; 1x.

J) Agassizia mossomi Cooke, 1942; UF 55007; adoral view of test; Suwannee Limestone; 1x.

K) Brissopsis sp.; UF 9195; aboral view of test imbedded in limestone; Suwannee Limestone; 1x.

L) Brissopsis sp.; UF 10719; aboral view of test imbedded in limestone; Suwannee Limestone; 1x.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UF 9195

Miocene Echinoids

Order Cidaroida Claus, 1880
Family Cidaridae Gray, 1825
Genus Prionocidaris A. Agassiz, 1863

Description: Test arched or low, more or less flattened at apex, thin and somewhat fragile. Primary tubercles noncrenulate adorally, weakly subcrenulate or noncrenulate aborally; areoles shallow, well separated save for lowermost two or three, which may be confluent. Pores distinctly conjugate or subconjugate. Primary spines usually long, tapering, with coarse thorns in longitudinal series; less commonly cylindrical, smooth or widened distally, or with thorns arranged in whorls; cortex thin; oral primaries with relatively long collar, tipped by rudimentary shaft. Secondary spines not adpressed, larger ones flattened, smaller ones spiniform. Tridentate pedicellariae slender; large globiferous pedicellariae without end tooth, or wanting; small globiferous with end tooth.

Florida species: P. cookei Cutress, 1976.

Comments: The species occurs in the Chipola and Torreya formations of the Florida panhandle. The specimens from the Torreya Formation are new stratigraphic records for the state, and are dominated by spines. These warrant closer examination to determine if they represent a new species.

Prionocidaris cookei Cutress, 1976
(Figure 3-14, A-C)

Material examined: UF 66632 (figured test fragment), UF 88540 (figured radioles), UF 101422 (figured test plates), UF 44645 (12 interambulacral plates), UF 44660 (4 radioles).

Description: Test medium size. Primary areoles more than half width of plate, those near peristome confluent. Scrobicular tubercles round, separated; secondary tubercles otherwise well spaced, of decreasing size to sutures, not horizontally aligned. Radioles moderately long, slender, tapered, sometimes dark-banded, and with regular longitudinal series of uniformly small or small and medium sized spinules. Collar often long, mottled, with low, oval nodules. Oral radioles not capped.

Gen. et sp. indet.
(Figure 3-14, D)

Material examined: UF 66579 (figured internal mold of single interambulacrum).

Formation: Chattahoochee Formation (uncertain).

Locality: Dry Creek 01 (JA010); Jackson County, FL; Oakdale Quadrangle, NE1/4, SW1/4, Sec. 11, T3N, R10W.

Collectors: T. Cassady and B. Shumaker.

Date: 7/10/93.

Description: Specimen consists of a poorly preserved internal mold of a single interambulacrum. Test medium size (portion preserved with height of approximately 35 mm), likely spherical. Interambulacral plates about twice as wide as long; slightly inflated. Few pore pairs visible adjacent to segments of adradial suture; zygopores transverse, elliptical shape, small, and closely spaced; pores appear relatively arranged in relatively straight column.

Comments: Overall preservation is poor, yet the general shape of the interambulacrum and its plates tends to indicate a unique regular echinoid. A

cidaroid species, Prionocidaris cookei, was described from the Miocene from Florida by Cutress (1976), and they have been reported from various Miocene units in the Caribbean (Cutress, 1980; Donovan, 1993). In Florida, cidaroid species are present in the Eocene (Phyllacanthus mortoni, Ocala Limestone), Miocene (Prionocidaris cookei, Chipola Formation), and Pliocene (Eucidaris tribuloides, Tamiami Formation). This fossil is too incomplete to allow a generic or specific identification to be proposed, but the familial assignment is reasonable based on the general arrangement and shape of the test plates as well as the pore pair orientation. Therefore, this fossil is a new stratigraphic record for the Chattahoochee Formation, and very likely a new taxonomic record for Florida as well since it is has very little similarity to the Chipola Formation species.

Gen. et sp. indet.
(Figure 3-14, E)

Material examined. --UF 66513 (figured; one incomplete radiole).

Formation: Shoal River Formation.

Locality: Shoal River Grotto (WL004); Walton County, FL; New Harmony Quadrangle, Sec. 4, T3N, R21W.

Collectors: G. Schmelz and W. Conway.

Date: 4-5/5/93

Description: The fossil consists of a single, incomplete radiole. Both proximal and distal ends missing (including base, collar, and milled ring). Longitudinal profile straight, with only very slight narrowing toward distal end. Shaft ornamented with multiple longitudinal rows of very small spinelets or

thorns, all oriented toward distal end; spinelets estimated at 0.1 to 0.2 mm long. Overall length of radiole is 18 mm.

Comments: Identification of the lower taxonomic levels for this fossil is not possible based only on this radiole. The spine has morphological characteristics such as the rows of spinelets that reflect features common to the cidaroids, and therefore I believe it is reasonable to assume this ordinal affiliation. However, without a more complete spine or additional tests or test fragments, more detailed identification cannot be completed. This fossil is included as a new stratigraphic record for the Shoal River Formation and as one of the taxa from the Miocene (but not as a new taxonomic record).

Order Arbacioida Gregory, 1900
Family Arbaciidae Gray, 1855
Genus Arbia Cooke, 1948

Description: Apical system probably dicyclic, pentagonal, encircling the periproct. Ambulacra narrower than the interambulacral areas throughout; poriferous zones uniserial, the zygopores forming a straight line above the ambius, arranged in slightly diagonal groups of three at and below it, not at all expaned at the peristome; zygopores one to each plate near the apex, three to each compound plate below; without sphaeridial pits. Tubercles imperforate, more abundant below the ambitus. Peristome small, circular, moderately notched.

Florida species: Arbia sp.

Comments: One unidentified species, herein referred to as Arbia sp., is present in the Chattahoochee Formation. This taxon is new to the Florida fossil record.

Arbia sp.
(Figure 3-14, F-G)

Material examined: UF 102309 (figured partial external mold (with associated RTV silicone rubber peel generated from the mold).

Formation: Chattahoochee Formation; beds 6 and 7.

Locality: Jim Woodruff Dam (JA003); Jackson County, FL; Chattahoochee Quadrangle, N1/2, Sec. 31, T4N, R6W.

Collectors: R. Portell, C. Oyen, and L. Anderson.

Date: 6/5/97.

Description: Test small to moderate size (mold corona from lower ambitus to near apical system approximately 17 mm tall); aboral surface subhemispherical in shape. Two interambulacral rows of primary tubercles; prominent boss and mamelon (possibly perforate); distinct scrobicular ring; two ambulacral rows of moderate marginal tubercles; secondary tubercles limited to area above and below ambitus. Interambulacral plates devoid of secondary ornamentation nearing apical system. Compound ambulacral plates with five to six zygopores each; pore pairs small, circular, and closely spaced, producing straight columns. No remnant of apical system, periproct, peristome, or aboral surface is present in the specimen.

Comments: This fossil consists only of an external mold of a portion of the aboral surface, therefore detailed analysis of its features is somewhat limited.

It should be noted, however, that the silicone rubber peel produced from the mold does indeed show the micro-morphology of that portion of the test that produced the mold. Based on close examination of features on both the mold and the peel, two different genera are possible matches for the fossil's characteristics. One potential match is Gagaria and the second is Arbia. A problem with using both of these genera as matches is that neither have been reported from the Miocene of Florida (although I also have described the affinity of a second unidentified regular echinoid fragment and spines from the Miocene Parachucla Formation with Gagaria in this dissertation). Cooke (1948) erected the genus Arbia based on fossils from the late Oligocene Chickasawhay Limestone in Alabama and the early Miocene Paynes Hammock Formation of Mississippi (Cooke, 1959). Since the Florida fossil described above is Miocene and matches some of the characteristics (at least those which are preserved in the moldic fossil) of Arbia, I have chosen to refer to the fossil as a questionable Arbia sp. until additional fossils can be collected and used for comparison.

Order Temnopleuroida Mortensen, 1942
Family uncertain
Genus Gagaria Duncan, 1889

Description: See Oligocene echinoid section for generic description.

Florida species: As many as three, undescribed species herein referred to as Gagaria sp.

Comments: These species are present in the Chattahoochee and Parachucla formations.

Gagaria sp. or Gagaria spp.
(Figure 3-14, H)

Material examined: UF 25339 (figured test fragment), UF 25130 (90 radioles or radiole fragments), UF 25498 (50 test fragments), UF 25514 (150 radioles).

Formation: Parachucla Formation.

Locality: White Springs (HA001); Hamilton/Columbia County, FL; White Springs West Quadrangle; W1/2, NW1/4, SW1/4, Sec. 7, T2S, R16E for UF 25339 and NW1/4, NW1/4, SW1/4, Sec. 7, T2S, R16E for UF 25130.

Collectors: R. Portell and G. Morgan (UF 25339), and G. Morgan (UF 25130)

Date: 1/13/89 (UF 25339) and 2/13/88 (UF 25130).

Description: The test fragment consists of a single, incomplete ambulacrum plate series, but is well-preserved and exhibits micro-morphological features clearly. Interporiferous zone with moderate-sized, crenulated marginal tubercles; two rows of small, non-ornate, inner tubercles adjacent to perradial suture; marginal tubercles scrobiculate with pronounced boss and mamelon. Pore pairs circular, nonconjugate with distinct septum; three or possibly four pairs per plate. Test fragment size limited to approximately 8x12 mm, and curvature of preserved section implies the overall size of complete test was small. Radioles small (maximum length approximately 17 mm), ranging from ovate to semi-bladed transversely; acetabulum conical; base smooth with narrow ring distally; most with smooth to slightly ornamented shaft.

Comments: Due to the limitations of identification based on this small and incomplete test fragment, only a tentative identification is offered as a potential species of Gagaria. This is an important biostratigraphic record because it represents the first Miocene record of this genus in the southeastern U.S. Although specific assignment is unlikely based on the current fossils, it is probable it also is a new species as well, and thereby increases the taxonomic record of the Miocene in Florida too.

Unidentified regular echinoid; cf. Gagaria sp.
(Figure 3-14, I-J)

Material examined: UF 60668 (figured incomplete internal mold).
Formation: Chattahoochee Formation; beds 6 and 7.

Locality: Jim Woodruff Dam (JA003); Jackson County, FL; Chattahoochee Quadrangle, N1/2, Sec. 31, T4N, R6W.

Collectors: R. Portell and J. Bryan

Date: 11/18/92.

Description: Incomplete internal mold of test; horizontal outline subpentagonal. Test small, subhemispherical, slightly concave adoral surface. Peristome approximately half to slightly greater than half of test diameter. Pore pairs small, round, closely set; produce ambulacra that become close together near peristome but diverge significantly at ambitus and higher on adapical surface.

Comments: Lower taxonomic identification of this specimen is not possible based on the preservation of the specimen. The overall test shape, the

subpentagonal outline, and the small pore pairs may indicate an affinity to Gagaria, though this can only be considered tentative at best. Clearly, the specimen is a regular echinoid, thereby representing the first stratigraphic record of such an echinoid within the Chattahoochee Formation. It also is possible this may be a new taxa since no Gagaria have been reported from the Miocene (except in this dissertation; see earlier Gagaria sp. description for fossils from the Parachucla Formation).

Family Echinidae Gray, 1825
Genus Psammechinus L. Agassiz and Desor, 1846

Description: Widest at circular ambitus; ambulacral plates trigeminate, with primary tubercle on each; buccal membrane densely plated, with contiguous or even imbricated plates; secondary radioles numerous, smooth; apical system dicyclic.

Florida species: Species indeterminate and generic identification only tentative.

Comments: Fossils are present in the Chipola Formation of northwestern Florida, and represent a new stratigraphic occurrence for the state and a potential new taxonomic record. Specimens consist only of plate fragments, thus will require much more detailed examination to determinate specific taxonomy.

cf., Psammechinus sp.
(Figure 3-14, K)

Material examined: UF 67463 (figured test fragment).

Formation: Chipola Formation.

Locality: Chipola 09 (CA018); Calhoun County, FL; Clarksville Quadrangle, SW1/4, Sec. 29, T1N, R9W.

Collectors: A. Murray and G. Murray.

Date: 9/30/94.

Description: One very small test fragment, approximately four mm long and wide. Pore pairs circular, closely spaced; poriferous zone in small-scale zigzag pattern, with zygopores tracking perimeter of marginal tubercles. Primary tubercles with relatively large mamelon, modest scrobicule and scrobicular ring; two to three secondary tubercles along perradial suture.

Comments: Although the preservation of the test fragment is good, the overall size greatly limits the identification of the echinoid from which it was detached. The general tubercle arrangement and pore pair distribution is similar to that of Psammechinus species described from the Eocene of South Carolina and the Pliocene of Virginia (Cooke, 1959). Although no Miocene species from the U.S. have been reported, this may be a new species that is yet undescribed. Until more complete specimens are collected, I can only consider this to be cf. Psammechinus sp. for this study. The fossil is included as one of the echinoid taxa from the Miocene and a new stratigraphic record for the Chipola Formation in the taxonomic total and stratigraphic records tally.

Unidentified regular echinoid.
(Figure 3-14, L-M)

Material examined: UF 1167 (figured internal mold).

Formation: Arcadia Formation (Tampa Limestone Member).

Locality: UF locality 2122; Hernando County, FL; near Brooksville, FL

Collector: Unknown.

Date: Unknown.

Description: Horizontal outline circular; aboral surface gently sloping dome, slightly flattened near apex. Ambulacra and poriferous zones relatively narrow throughout; widest at ambitus, and nearly closing at apical system and peristome. Interambulacral plates approximately twice as wide as high; interambulacral zone about double the width of ambulacral zone. Pore pairs circular; unable to view specific arrangement. Peristome approximately half as wide as diameter. Test diameter approximately 39 mm and height 23 mm.

Comments: Most of the internal mold is poorly preserved, with only isolated areas showing any detailed morphology. The general outline, shape, and dimensions are similar to species of Arbacia, but the absence of large primary tubercle molds on the fossil is not expected, even on an imperfectly preserved mold. Due to the limited morphological features visible, I refer to this fossil as an unidentified regular echinoid only and will withhold lower taxonomic identification until better specimens can be collected. The specimen is counted as a new stratigraphic record for the Arcadia Formation, and also is counted as a unique species for the Miocene taxonomic list of echinoids.

Order Clypeasteroida A. Agassiz, 1872
Family Clypeasteridae L. Agassiz, 1835
Genus Clypeaster Lamarck, 1801

Description: See Oligocene echinoid section for generic description.

Florida species: C. concavus Cotteau, 1875 and C. sp.

Comments: The species C. concavus is present in the Chipola Formation, and the Clypeaster sp. fossils are present in the Chattahoochee Formation. This unidentified species also represents a new stratigraphic record of Clypeaster in the Chattahoochee Formation, and may be a new taxonomic record if it is an undescribed species.

Clypeaster concavus Cotteau, 1875
(Figure 3-15, A-B)

Material examined: UF 65864 (figured test), UF 40318 (test fragment), UF 65865 (test), UF 65867 (test).

Description: Horizontal outline oval to subpentagonal; upper surface moderately inflated, petals slightly swollen; lower surface gently rounded near the margin, more or less deeply concave around the peristome, ambulacral grooves conspicuous; margin rounded. Apical system pentagonal, central; five genital pores at the corners of the central madreporite. Petals broad, lanceolate, extending about two-thirds the way to the margin, strongly convex near the tips; poriferous zones rather broad, completely closed at the apex, nearly closed distally; inner pores small, circular; outer pores larger, oval; pores conjugate; interporiferous zones more than twice as wide as the poriferous zones at the widest part. Peristome central, small. Periproct circular or transversely oval; near the margin. Tubercles crowded, sunken, smaller on the upper surface than on the lower; one row between each two pairs of zygopores.

Clypeaster sp.
(Figure 3-15, C-D)

Material examined: Eleven internal molds (weathered and incomplete); UF 40444 (figured internal mold), UF 66578 (internal mold), UF 66580, UF 66582, UF 97927.

Formation: Chattahoochee Formation.

Locality: Dry Creek 01 (JA010); Jackson County, FL; Oakdale Quadrangle, NE1/4, SW1/4, Sec. 11, T3N, R10W.

Collectors: T. Cassady, B. Shumaker, and C. Shumaker.

Date: 5/90 (for UF 40444 only).

Description: Test medium in size; horizontal outline subpentagonal; aboral surface relatively flat near ambitus, becoming inflated at apical system. Margins relatively thinner than average species of genus, yet thick enough for gradual rounding. Adoral surface clearly concave. Apical system located slightly anterior of center. Ambulacral petals broadly lanceolate, closed apically and slightly open distally; pores circular to subelliptical, conjugate, with each pair diverging to maximum at approximate midpoint of petal; outer pore more distal than inner pore. Petal length subequal and estimated as two-thirds to three-quarters the distance to test margin; no discernible curvature. Tubercles small to medium size, relatively densely spaced. Test length of longest specimen approximately 55 mm for defined mold only; the overall external test length was likely 10-20 mm greater than the internal mold length.

Comments. All specimens of this species are incomplete internal molds with poor to good general preservation. The specimens show some similarity to

the Miocene species C. concavus (see specific description above), but are thinner than C. concavus at the test margin and the petals of the molds are more uniform in dimension than those of C. concavus. Therefore, I interpret these molds as a new species awaiting formal description, and have included this undescribed species as a new stratigraphic record for the Chattahoochee Formation as well as a new taxonomic record.

Gen. et sp. indet.
(Figure 3-15, E-F)

Material examined: UF 23086 (figured incomplete test).

Formation: Coosawhatchie Formation.

Locality: Brooks Sink (BF001); Bradford County, FL; Brooker Quadrangle, SW1/4, SW1/4, Sec. 12, T7S, R20E; east wall of sinkhole, bed 13.

Collector: R. Portell.

Date: 1/14/88.

Description: Single juvenile test, very small (approximately 5 mm diameter); central test area missing both apically and adorally. Horizontal outline subcircular; widest posterior of center; evidence of initial stages of ambulacral notches in ambulacrum I and V; posterior margin somewhat truncated. Test margin proportionally medium in thickness, rounded. Both adoral and aboral surface flat (although both surface incomplete). Detailed micromorphology not visible (i.e., petals, apical system, tubercles, and peristome); periproct positioned just posterior of midpoint between peristome and test margin, longitudinally elliptical in orientation.

Comments: The general shape of this fossil is similar to what would be expected in a clypeasteroid species, and is similar to other Miocene species such as Abertella aberti previously reported from the Coosawhatchie Formation (Jones and Portell, 1988). Since juveniles are not fully developed morphologically and this specimen is incomplete, I have chosen to only list its identification to the ordinal level at this time. Therefore, I do not include this fossil as a new stratigraphic record, new taxonomic record, or as a unique species for the overall Miocene diversity value (if it is Abertella aberti, it has already been included from this unit in the Miocene). From a biostratigraphic perspective, the only significance of this fossil is its presence at the Brooks Sink locality. As work continues, additional specimens may be recovered that will provide better comparative material for identification purposes, and it may or may not prove to be a new species for the Miocene echinoids of Florida.

Family Fibulariidae Gray, 1855
Genus Echinocyamus van Phelsum, 1774

Description: Test moderately flattened; hydropores few, not in groove; periproct between first and second pair of coronal plates; petals poorly defined in some forms, pore pairs usually oblique; no spicules in tube feet; five pairs of internal radiating partitions; in some species females with aboral marsupium.

Florida species: E. chipolanus Cooke, 1942.

Comments: This species is present in the Chipola Formation. This is one of the rare species reported from Florida that forced me to be solely dependent upon previously published information (i.e., Cooke, 1942) as a record

of its presence in Florida. No samples were personally collected, and no fossils are part of the FLMNH collection or other museum and personal collections I examined as part of my research.

Echinocyamus chipolanus Cooke, 1942

Material examined: No specimens available in the FLMNH collection.

Description: Test small, outline broadly oval, gently arched above, flatter below; surface covered with proportionately large tubercles; strengthened by internal marginal partitions. Genital pores four in number, widely spaced. Ambulacral areas obscure; poriferous zones of each area apparently widely diverging. Peristome about one-third the total width, nearly circular. Periproct very slightly closer to the margin than to the peristome, rather large, slightly pointed posteriorly.

Family Echinarachniidae Lambert, 1914
Genus Echinarachnius Gray, 1825

Description: Petals lyrate, about 0.6 length of radius; periproct marginal, between third pair coronal plates; food grooves with straight trunk, two equal lateral branches near margin; contact of coronal interambulacral plates with primordial plates very variable; posterior area usually discontinuous; three or four interambulacral and five or six ambulacral coronal plates on oral surface.

Florida species: cf. Echinarachnius sp.

Comments: This tentatively identified genus is present in the Chipola Formation.

cf. Echinarachnius sp.
(Figure 3-15, G)

Material examined: UF 67464 (figured test), UF 67465 (test), UF 67483 (test).

Formation: Chipola Formation.

Locality: Chipola 09 (CA018); Calhoun County, FL; Clarksville Quadrangle, SW1/4, Sec. 29, T1N, R9W.

Collectors: A. Murray and G. Murray.

Date: 9/30/94.

Description: Test subcircular to subpentagonal; slight invagination along margin of ambulacrum I and V; widest point posterior of apical system in approximate locations of interambulacrum 1 and 4. Apical system slightly inflated; located just anterior of test center. Petaloid ambulacra imperfectly developed (all are juveniles); petal length estimated to extend two-thirds the distance to margin in ambulacra II, III, and IV, while only half the distance to margin in posterior petals. Tubercles proportionally medium size, moderately spaced on aboral and adoral surfaces. Peristome slightly eccentric anteriorly; medium size (though may have been expanded during compaction and preservation), circular in outline. Periproct or possible posterior notch on posterior margin; small diameter; elliptical shape.

Comments: All three specimens are juveniles and clearly not fully developed morphologically. This leads to uncertainty in identification of the species since allometric growth may produce somewhat different morphological proportions in adults than are observed in these fossils. Three genera are

possible matches for the test characteristics, including Abertella, Protoscutella, and Echinarachnius. Of these possibilities, Echinarachnius and Protoscutella are the closer matches morphologically, but Protoscutella only is known from the Eocene while Echinarachnius has been reported from the Miocene in the western U.S. and Japan. Abertella is present in the Miocene of Florida, but these fossils are distinctly different in general test shape from Abertella. If these differences are simply a reflection of comparison between a juvenile morphology and an adult morphology, only collecting additional fossils (that are adults) will allow the appropriate comparisons and a solution to this taxonomic question. Therefore, I tentatively assign this set of fossils to the genus Echinarachnius and include them as a new taxonomic record for the Miocene of Florida and a new stratigraphic record for the Chipola Formation.

Family Mellitidae Stefanini, 1911
cf. Mellitdae, gen. et sp. incertae.
(Figure 3-15, H-I)

Material examined: UF 17635 (figured 2 test fragments).

Formation: Statenville Formation.

Locality: Suwannee River Mine (HA002); Hamilton County, FL; Benton/Genoa Quadrangles, T1N/1S, R15/16E.

Collector: R. Portell.

Date: 4/9/88.

Description: Two small, marginal test fragments; surface weathered, thereby removing tubercles and micromorphology features. Adoral and aboral surfaces flat, terminating in thin, sharp margin, one to two mm thick.

Comments: Specimens clearly identifiable as derived from flat sand dollars, but no identification beyond familial level can be determined. Other mellitids are known from the Miocene (see descriptions within this section), but until specimens that are more complete are available, the identification will remain uncertain. The fossils are included as new stratigraphic records from the Statenville Formation, but are not included in the Miocene species diversity total due to the limited taxonomic resolution (indeterminable as unique species).

Family Abertellidae Durham, 1955
Genus Abertella Durham, 1953

Description: Petals about 0.7 length of radius; posterior marginal indentations most prominent; periproct between second serial pair post-basicoronal plates; interambulacra about 0.5 width of ambulacra at ambitus.

Florida species: Abertella. aberti (Conrad, 1842) and Abertella spp.

Comments: Fossils of A. aberti are present in the Arcadia and Peace River formations. Also reported by Cooke (1959, p. 45) from the Chipola Formation along the Sopchoppy River in Wakulla County, but this very likely is an inaccurate report, since the Chipola Formation is not present in that area. Therefore, I do not include this species as part of the echinoid fauna of the Chipola. A second category of fossils awaiting identification are possible Abertella species (UF 74785) collected from the Chipola, Torreya, and

Coosawhatchie formations. These fossils are difficult to identify to genus as well as to species, and will require further detailed preparation and examination. The specimens have been tentatively identified as possible Protoscutella sp. (B. Carter, pers. comm., 1995), but I am not convinced that is the best choice, and prefer to include them as an unidentified or undescribed species of Abertella.

Abertella aberti (Conrad, 1842)
(Figure 3-16, A-B)

Material examined: UF 5363 (figured test), UF 104444 (figured test), UF 14501 (test), UF 25417 (36 test fragments), UF 60072 (test), UF 60073 (test).

Description: Test shield shaped; horizontal outline semicircular in front, fluted behind, with a deep posterior notch of variable width and shallower rounded indentations in the posterior ambulacra; upper surface slightly inflated in the apical region, nearly flat marginally; oral surface flat; margin thin. Apical system fused, star shaped, with the points protruding between the petals and four genital pores at the ends, usually somewhat raised. Petals lanceolate, extending about two-thirds of the radius; pores small, circular, deeply conjugate, inner row nearly straight, outer row broadly arched; poriferous zones wider than the interporiferous zones, moderately open at each end. Ambulacra widely expanding beyond the petals. Interambulacra narrowing from the outer ends of the petals to the margin, slightly expanding within the margin on the oral face but interrupted by two long postbasicoronal ambulacral plates. Each submarginal plate of the oral side contains a maze of internal passageways. Peristome central, small, circular; surrounded by five radiating food grooves, which bifurcate

at the ends of the basicoronal plates and curve broadly almost to the margin, where they branch repeatedly. Periproct on the oral side about three-quarters of the radius from the margin, the distance from the margin varying with the depth of the posterior notch.

cf. Abertella sp.
(Figure 3-16, C-D)

Material examined: UF 25296 (figured test fragment).

Formation: Torreya Formation.

Locality: Gunn Farm Mine (Milwhite Company) (GD006); Gadsden County, FL; Dogtown Quadrangle, NE1/4, N1/2, Sec. 74, T4N, R3W.

Collector: D. Bryant.

Date: 8/19/88.

Description: Single test fragment (approximately 30 mm by 39 mm); aboral surface flat, sloping gently away from apical system; adoral surface flat. Tubercles very small, densely covering both aboral and adoral surfaces. Small area of poriferous zone visible; pores very small, circular, conjugate; outer pore of pair eccentric marginally relative to inner pore; distal terminus of petal located significantly adapically from margin; petal apparently at least partially open at end. Test margin interpreted to be thin, possibly sharp.

Comments: This fossil collected from the Torreya Formation is small, but several interpretations can be made regarding its possible taxonomic affinity. The specimen clearly is a flat sand dollar variety of clypeasteroid with a thin margin. The only Miocene genus known from this age of material with a

relatively thin test margin is Abertella. A second characteristic of importance is the distance the terminal end of the petal lies from the test margin. In species of Abertella (such as the Miocene A. aberti), this petal-to-margin distance is at least moderate. For example, in many cases it ranges from 10 mm to over 20 mm, and in the specimen described above this distance is 17 mm. The original complete individual must have been relatively large overall, and species such as A. aberti are among the larger clypeasteroid species with respect to test length and body size. Therefore, I interpret this fossil as a species awaiting identification, but likely a within the genus Abertella, and thus refer to it as cf. Abertella sp. It may indeed reflect a new species rather than a new occurrence of a previously described species. This genus has been reported from the Chipola Formation, but the description herein is a new stratigraphic record from the Torreya Formation. I also have counted this as a unique species with regard to the overall Miocene diversity, but it is not considered a new taxonomic record at this time.

unidentified Clypeasteroida; cf. Abertella sp.
(Figure 3-16, E)

Material examined: UF 23085 (figured test fragment; 70 test fragments total in lot).

Formation: Coosawhatchie Formation.

Locality: Brooks Sink (BF001); Bradford County, FL; Brooker Quadrangle, SW1/4, SW1/4, Sec. 12, T7S, R20E; east wall of sinkhole, bed 13.

Collector: R. Portell.

Date: 1/14/88.

Description: Many very small test fragments (largest dimensions of 14 mm by 12 mm). Adoral and aboral surfaces flat; tubercles small, circular, closely packed on surfaces. Possible marginal fragments thin, sharp.

Comments: These fossils are similar to fragments of other clypeasteroid echinoids found in the Coosawhatchie Formation, particularly Abertella aberti fragments. Due to the small size of the fragments, I refer to these fossils as cf. Abertella sp., recognizing they may indeed be part of A. aberti individuals known to occur in the Coosawhatchie Formation. These fossils are not included in any of my diversity or stratigraphic records counts since the generic or specific identification is uncertain, and because the most likely species already has been verified and included in such tabulations.

Order Cassiduloida Claus, 1880
Family Cassidulidae L. Agassiz and Desor, 1847
Genus Rhyncholampas A. Agassiz, 1869

Description: See Oligocene echinoid section for generic description.

Florida species: R. chipolanus Oyen and Portell, 1996, Rhyncholampas sp. cf. R. chipolanus, and Rhyncholampas sp.

Comments: The species R. chipolanus is present in the Chipola Formation and the unidentified species of Rhyncholampas is present in the Arcadia and Peace River formations. The Rhyncholampas sp. fossils are internal molds with relatively poor preservation, thereby making specific identification rather difficult. It is possible that these specimens represent new records of R.

chipolanus from the central part of Florida, but until specimens are collected with better preservation, this comparison cannot be completed in detail. Therefore, the Rhyncholampas sp. fossils are new stratigraphic records of the genus in both the Arcadia and Peace River formations, and possibly a new taxonomic record as well.

Rhyncholampas chipolanus Oyen and Portell, 1996
(Figure 3-16, F-G)

Material examined: UF 66633 (figured test).

Description: Test large, width relatively uniform; margin relatively sharp and angular in posterior, subrounded to moderately truncated along lateral margins; highest point at apical system, slightly anterior of test center; sides slope moderately, with shallower slope in upper half and slightly steeper slope in lower half of test. Apical system located central to slightly anterior of test; compact size. Petals well developed, broad, lanceolate, with greatest width approximately 35 percent of petal length; petals I and V longest, III slightly shorter, and II and IV shortest; petals extend approximately 65 percent of distance to test margin; petal widths nearly equal, with petal III 25 percent narrower than others; petals almost closed at distal end. Periproct supramarginal; width approximately 1.5x greater than height; pentagonal shape, with apex pointing toward apical system; slight groove extending from periproct opening to posterior margin. Peristome moderately anterior, pentagonal, and depressed; width approximately 1.7x greater than length. Floscelle with bourrelets distinct and pointed. Adapical tubercles small and uniformly

distributed; limited visible adoral tubercles near peristome distinctly larger. Species characterized by slightly truncated oval outline, moderately sloping sides with focused peak at apical system, depressed adoral surface, nearly closed lanceolate petaloid ambulacra, and pentagonal periproct.

<u>Rhyncholampas</u> sp. cf. <u>R</u>. <u>chipolanus</u> Oyen and Portell, 1996.
(Figure 3-17, A-B)

Material examined: UF 5373 (figured internal mold), UF 10111 (figured internal mold).

Formation: Arcadia Formation.

Locality: Ft. Green 13 Dragline (PO002); Polk County, FL; Baird Quadrangle, Sec. 2, T32S, R23E.

Collectors D. Jones (UF 5373) and S. King (UF 10111).

Date: 2/14/87 and 1/86, respectively.

Description: Test truncated oval in horizontal outline; widest point posterior of center; test width/length ratio approximately 0.91 and height/length ratio 0.54; aboral surface inflated, somewhat conical and steeply sloping with peak anterior of center; adoral surface dominantly obscured but apparently slightly depressed. Apical system anterior of center; gonopores not preserved. Petaloid ambulacra lanceolate, narrowing at distal end without closing; conjugate pore pairs; petals imperfectly preserved but apparently subequal in length, extending two-thirds to three-quarters the distance to margin. Periproct supramarginal, wider than high, with shallow groove from opening to posterior margin; peristome not preserved.

Comments: I interpret these fossil internal molds to represent a species of Rhyncholampas, though imperfect preservation reduces the reliability of specific identification. Three described species have similar morphological characteristics, including one Miocene species (R. chipolanus) and two Pliocene taxa (R. ayresi and R. evergladensis). The closest morphological and temporal match of the three is R. chipolanus from the Chipola Formation in north Florida (see the species description in this section). One aspect of these Rhyncholampas fossils that is somewhat unusual is the moldic preservation, and this inhibits detailed comparisons with other fossils from the state. Therefore, I refer to these specimens as Rhyncholampas sp. cf. R. chipolanus and include them as a new stratigraphic record for the Arcadia Formation and as part of the diversity total representing R. chipolanus, not a new taxonomic record.

Rhyncholampas sp.
(Figure 3-17, C)

Material examined: UF 12992 (figured test fragment), UF 10671 (test fragment).

Formation: Peace River Formation.

Locality: Zolfo Springs (HR001); Hardee County, FL; Zolfo Springs Quadrangle, Sec. 27/28, T34S, R25E.

Collector: C. Howlett.

Date: Unknown.

Description: Test fragmented, weathered, and incomplete; interpreted as relatively large. Aboral surface inflated, broadly curving; moderately tall. Apical

system destroyed. Isolated remnants of petaloid ambulacra present; conjugate pore pairs, circular; outer and inner pores diverging at maximum width of petal, outer pore eccentric marginally as compared with inner pore of pair; pores tightening distally and presumed similar proximally; petals lanceolate, not completely closed at distal end. Adoral surface dominantly flat with slight concavity near peristome. Peristome damaged but located anterior of center; bourrelets present; periproct destroyed. Tubercles small, closely spaced both adorally and aborally.

Comments: This fossil is significantly damaged, thereby preventing full identification. However, the overall shape of the remaining portion is identifiable as a species of Rhyncholampas. The Miocene of Florida only has one species reported (R. chipolanus Oyen and Portell, 1996 from the Chipola Formation; see description in this section), and this specimen may be a new record of C. chipolanus for the Peace River Formation. Without a better preserved specimen, it is impossible to fully compare with other species and must be left as species indeterminate. Herein I consider this fossil as a new stratigraphic record for the Peace River Formation (as the first stratigraphic record of Rhyncholampas in the unit), but do not include it as a new taxonomic record for the Miocene nor as part of the diversity total for the epoch.

Order Spatangoida Claus, 1876
Family Schizasteridae Lambert, 1905
Genus Agassizia L. Agassiz and Desor, 1847

Description: See Eocene echinoid section for generic description.

Florida species: Agassizia sp.

Comments: The species is present in the Arcadia Formation (Miocene), from the Dean's Trucking Pit locality in southern Florida. This represents a new stratigraphic record, and likely a new taxonomic record for Agassizia in the Miocene (since no Miocene species are known from the southeastern U.S.).

Agassizia sp.
(Figure 3-17, D)

Material examined: UF 28401 (figured incomplete internal mold).

Formation: Arcadia Formation.

Locality: Dean's Trucking Pit (SO006); Sarasota County, FL; Laurel Quadrangle, SW1/4, Sec. 22, T38S, R19E.

Collectors: R. Portell and P. Whisler.

Date: 8/16/86.

Description: Internal mold, incomplete and compacted. Horizontal outline interpreted as subcircular to subovate. Aboral surface inflated, hemispherical-shaped, sloping steeply toward margins; margins broadly rounded; adoral surface not present in sample. Apical system posterior of center; plate arrangement not preserved. Ambulacra slightly depressed; ambulacrum III poorly developed; ambulacra II and IV longest, extending two-thirds the distance to margin; anterior paired ambulacra diverging at approximately 40-45° from anterior-posterior medial line at proximal end, curving slightly toward posterior at distal end; posterior ambulacra pair shorter, slightly wider, and approximately half the length of anterior pair, and diverging at about 40-45° from medial line. Entire

adoral surface absent; posterior margin dominantly crushed or absent. Overall test size small with test length approximately 13 mm and width approximately 14 mm.

Comments: Although this fossil is poorly preserved, the size, shape, and petaloid ambulacra support the identification as a species of Agassizia. The genus has been reported from the Eocene (A. clevei), Oligocene (A. mossomi) and Pliocene (A. porifera) of Florida, and with this description is a new record from the Miocene. The preservation is too poor to define the specific level identification, and therefore I refer to the fossil only as Agassizia sp. It represents a new stratigraphic record from the Arcadia Formation, and likely is a new taxonomic record (and counted as such herein) since no other Miocene species are known from the Gulf and Atlantic Coastal Plains of the southeastern U.S.

Family Brissidae Gray, 1855
Genus Brissopatagus Cotteau, 1863

Description: Differs from Eupatagus in having large depressions in front of anterior petals or in front of all petals.

Florida species: Brissopatagus sp.

Comments: The species is present in the Chattahoochee Formation along Dry Creek in northern Florida.

Brissopatagus sp.
(Figure 3-18, A-B)

Material examined: UF 97921 (figured internal mold), UF 40441 (figured internal mold), UF 66568 through 66577 (one internal mold each).

Formation: Chattahoochee Formation.

Locality: Dry Creek 01 (JA010); Jackson County, FL; Oakdale Quadrangle, NE1/4, SW1/4, Sec. 11, T3N, R10W.

Collectors: T. Cassady, B. Shumaker, and C. Shumaker.

Date: 5/90.

Description: Horizontal outline asymmetrically oval; narrowest and truncated posteriorly, widest slightly anterior of center. Aboral surface broadly curving at margin, somewhat elevated, and flattening near center of test; apical system anteriorly eccentric, at one-third the length from anterior margin. Petaloid ambulacra shallowly depressed; anterior pair (II and IV) diverge at about 160º; posterior pair (I and V) diverge at about 50º; ambulacrum III more poorly developed, flush with surface, leading into small anterior sulcus at test margin. Petals curve slightly toward anterior at distal ends; anterior pair curvature more pronounced than posterior pair; posterior petals shorter than anterior pair, extending approximately half the distance to margin; anterior pair extend three-quarters the distance (or slightly more) to margin. Petals lanceolate, narrowing minimally at distal end yet remaining open. Zygopores circular, moderately spaced; outer pore slightly advanced toward margin. Adoral surface moderately flattened; locally depressed around peristome, and raised along a medial ridge extending from peristome to posterior margin. Peristome at anterior quarter; width approximately double the length; curved toward posterior; labrum not conspicuously overhanging. Periproct inframarginal to supramarginal at posterior truncation (rarely preserved well enough to describe). Tubercles not preserved.

Comments. These internal molds are moderately well preserved, allowing identification to the generic level of Brissopatagus. One species in this genus was reported by Checchia-Rispoli (1947) from Oligocene-Miocene rocks in northern Africa. However, no species have been reported from the Miocene of the Caribbean or the southeastern U.S. and, therefore, it is likely these fossils are a new species. Thus, I refer to these fossils as Brissopatagus sp. herein and include them as a new stratigraphic record for the Chattahoochee Formation, a new taxonomic record for the genus, and count this unnamed species in my diversity total for the Miocene of Florida.

cf. Brissidae; gen. et sp. indet.
(Figure 3-18, C-D)

Material examined: UF 67379 (figured test fragment), UF 44622 (figured test fragment).

Formation: Chipola Formation.

Locality: UF 67379: Farley Creek 07 (CA002); Calhoun County, FL; Clarksville Quadrangle, SW1/4, NE1/4, Sec. 21, T1N, R9W. UF 44622: Tenmile Creek 02 (CA003); Calhoun County, FL; Altha West Quadrangle, N1/2, Sec. 11/12, T1N, R10W.

Collectors: R. Portell (UF 67379) and Brooks, Scolaro, and Dimmick (UF 44622).

Date: 4/29/94 and 11/9/73, respectively.

Description: The single test fragment (UF 67379) is a coherent plastron from posterior adoral surface. Ridge reduced, peak near posterior margin of

plate; small tubercles of fasciole distributed throughout, largest near plate margins. Second lot (UF 44622) dominated by very small plate fragments. Fragments covered by closely spaced tubercles; tubercles with pronounced, cylindrical boss, distinct parapet, and enlarged, perforate mamelon.

Comments: This set of fossils is so limited with respect to overall test morphology that only general statements regarding identification can be provided. The single plastron is similar to features found in various species of the family Brissidae in the order Spatangoida. Relatively few species of brissids have been reported from Miocene units in the U.S. and the Caribbean. One brissid was described and named from a possible Miocene formation in South Carolina by Cooke in 1959, that he named Spatangus glenni Cooke, but has since been revised to Brissus glenni (Cooke). The plastron of Cooke's species is morphologically similar to the one reported herein from the Chipola Formation, and may be closely related or possibly the same taxon. The second group of test fragments (UF 44622) are not distinct taxonomically, but are the appropriate size to have been part of one of the fascioles on a brissid (perhaps the subanal fasciole or the marginal fasciole). Specimens that are significantly more complete are required before any lower taxonomic identifications can be proposed for these fossils. The fossils are included as a new stratigraphic record for the Chipola Formation (although previously mentioned in a non-specific manner in Oyen and Portell, 1996, p. 60), as a possible new taxonomic record, and as a unique species for the Miocene diversity total.

Figure 3-14. Miocene regular echinoids.

A) Prionocidaris cookei Cutress, 1976; UF 66632; lateral view of test fragment; Chipola Formation; 1.5x.

B) Prionocidaris cookei Cutress, 1976; UF 88540; four incomplete radioles; Chipola Formation; 1.5x.

C) Prionocidaris cookei Cutress, 1976; UF 101422; exterior of three disarticulated, imperforate test plates; Chipola Formation; 1.5x.

D) CIDAROIDA, gen. et sp. indet.; UF 66579; lateral view of dolomitized, partial internal mold of test; Chattahoochee Formation; 1x.

E) CIDAROIDA; gen. et. sp. indet.; UF 66513; lateral view of incomplete radiole; Shoal River Formation; 2.x.

F) Arbia sp.; UF 102309; lateral view of dolomitized, partial external mold of test; Chattahoochee Formation; 1x.

G) Arbia sp.; UF 102309; lateral view of RTV silicone rubber peel made from partial external mold mentioned above; 1x.

H) Gagaria sp.; UF 25339; lateral view of test fragment; Parachucla Formation; 2x.

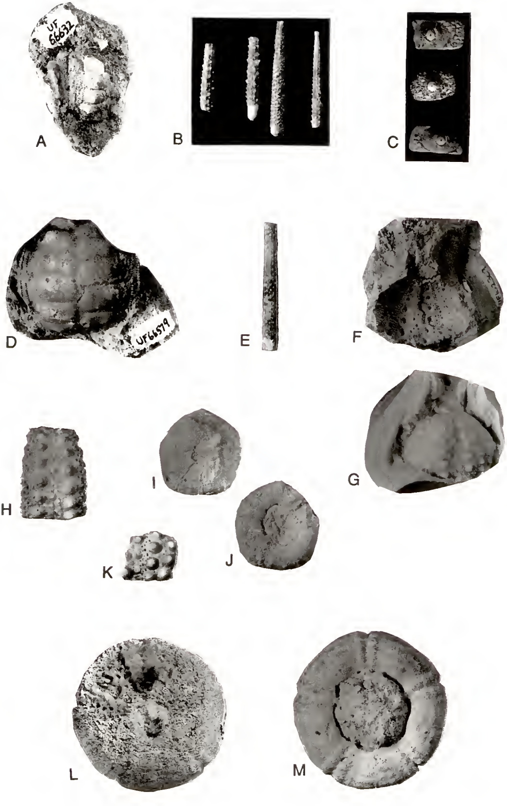
I) cf. Gagaria sp.; UF 60668; aboral view of internal mold of test; Chattahoochee Formation; 1x.

J) cf. Gagaria sp.; UF 60668; adoral view of internal mold of test; Chattahoochee Formation; 1x.

K) cf. Psammechinus sp.; UF 67463; lateral view of test fragment; Chipola Formation; 3x.

L) Unidentified regular echinoid; UF 1167; aboral view of internal mold of test; Arcadia Formation; 1x.

M) Unidentified regular echinoid; UF 1167; adoral view of internal mold of test; Arcadia Formation; 1x.


UF 66632
A
B
C
UF66579
D
E
F
G
H
I
J
K
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M

Figure 3-15. Miocene irregular echinoids.

A) Clypeaster concavus Cotteau, 1875; UF 65864; aboral view of test; Chipola Formation; 1x.

B) Clypeaster concavus Cotteau, 1875; UF 65864; adoral view of test; Chipola Formation; 1x.

C) Clypeaster sp.; UF 40444; aboral view of dolomitized, partial test; Chattahoochee Formation; 1x.

D) Clypeaster sp.; UF 66578; adoral view of dolomitized, partial test; Chattahoochee Formation; 1x.

E) Fam., gen., et sp. indet.; UF 23086; aboral view of incomplete, juvenile test; Chipola Formation; 3x.

F) Fam., gen., et sp. indet.; UF 23086; adoral view of incomplete, juvenile test; Chipola Formation; 3x.

G) cf. Echinarachnius sp.; UF 67464; aboral view of juvenile test; Chipola Formation; 3x.

H) cf. Mellitidae; UF 17635; test fragment; Statenville Formation; 2x.

I) cf. Mellitidae; UF 17635; test fragment; Statenville Formation; 2x.

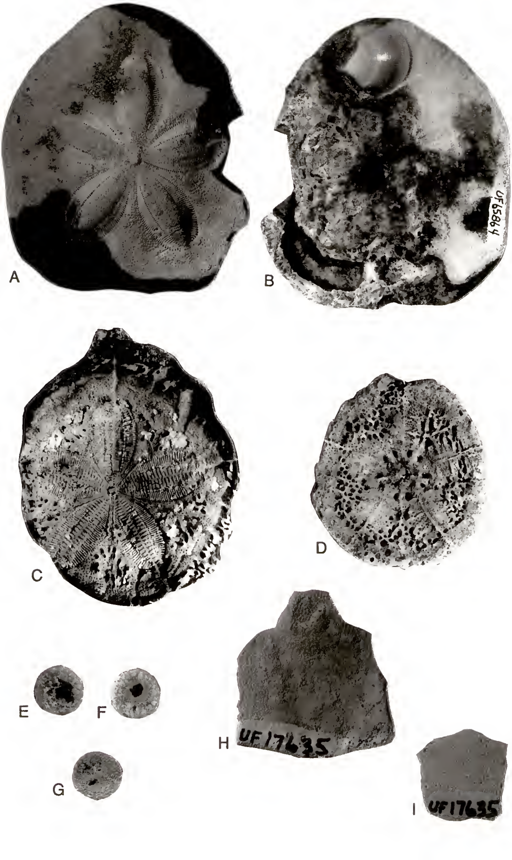

A
B
UF65864
C
D
E
F
G
H
UF17635
I
UF17635

Figure 3-16. Miocene irregular echinoids.

A) Abertella aberti (Conrad, 1842); UF 5363; aboral view of test; Arcadia Formation; 0.75x.
B) Abertella aberti (Conrad, 1842); UF 104444; adoral view of test; Arcadia Formation; 0.75x.
C) cf. Abertella sp.; UF 25296; aboral view of test fragment; Torreya Formation; 1x.
D) cf. Abertella sp.; UF 25296; adoral view of test fragment; Torreya Formation; 1x.
E) Unidentified Clypeasteroidea; cf. Abertella sp.; UF 23085; test fragment; Coosawhatchie Formation; 2x.
F) Rhyncholampas chipolanus Oyen and Portell, 1996; UF 66633; aboral view of test; Chipola Formation; 1x.
G) Rhyncholampas chipolanus Oyen and Portell, 1996; UF 66633; adoral view of test; Chipola Formation; 1x.
H) Rhyncholampas chipolanus Oyen and Portell, 1996; UF 66633; lateral view of test; Chipola Formation; 1x.

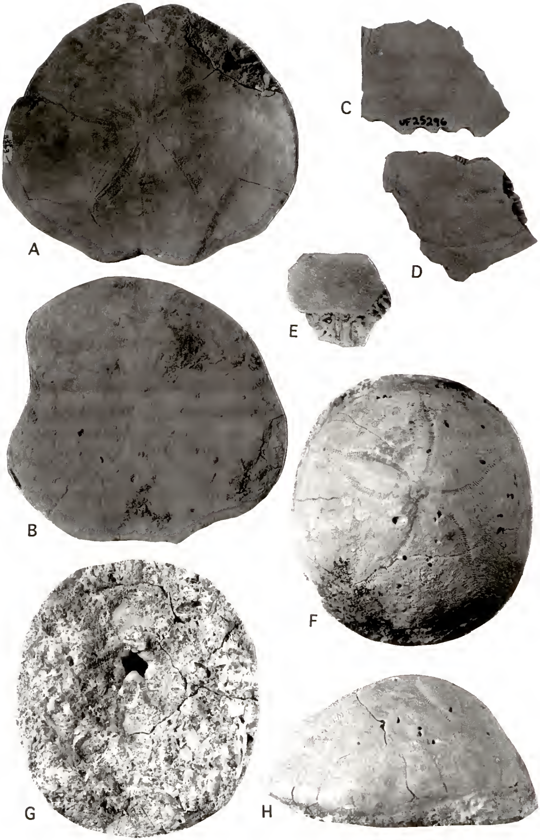

A
C
UF25296
D
E
B
F
G
H

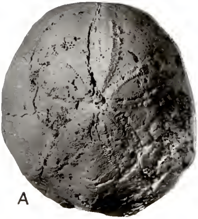
Figure 3-17. Miocene irregular echinoids.

A) Rhyncholampas sp. cf. R. chipolanus Oyen and Portell, 1996; UF 5373; aboral view of dolomitized, incomplete internal mold of test; Arcadia Formation; 1x.

B) Rhyncholampas sp. cf. R. chipolanus Oyen and Portell, 1996; UF 10111; aboral view of dolomitized, incomplete internal mold of test; Arcadia Formation; 1x.

C) Rhyncholampas sp.; UF 12992; lateral view of incomplete test embedded in sandstone matrix; Peace River Formation; 1x.

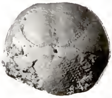
D) Agassizia sp.; UF 28401; aboral view of dolomitized, incomplete internal mold of test; Arcadia Formation; 2x.



A

B

C



D

Figure 3-18. Miocene irregular echinoids.

A) Brissopatagus sp.; UF 97921; aboral view of dolomitized, internal mold of test; Chattahoochee Formation; 1x.

B) Brissopatagus sp.; UF 40441; adoral view of dolomitized, internal mold of test; Chattahoochee Formation; 1x.

C) cf. Brissidae; gen. et sp. indet.; UF 67379; adoral view of test plastron; Chipola Formation; 1x.

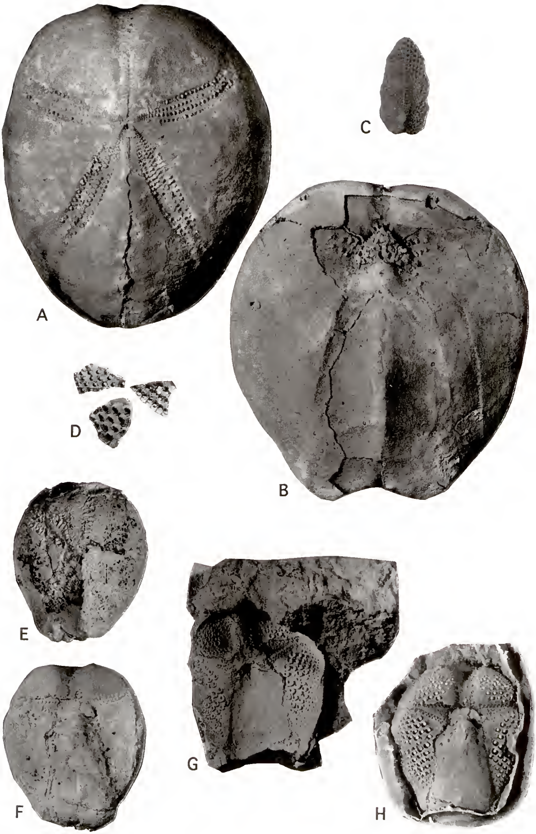
D) cf. Brissidae; gen. et sp. indet.; UF 44662; test fragments; Chipola Formation; 2x.

E) Lovenia clarki (Lambert, 1924); UF 61083; aboral view of internal mold of test; Chattahoochee Formation; 1x.

F) Lovenia clarki (Lambert, 1924); UF 61083; adoral view of internal mold of test; Chattahoochee Formation; 1x.

G) Lovenia clarki (Lambert, 1924); UF 61083; adoral view of external mold of test; Chattahoochee Formation; 1x.

H) Lovenia clarki (Lambert, 1924); UF 61083; RTV silicone rubber peel of adoral view of internal mold of test; 1x.


A
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Family Loveniidae Lambert, 1905
Genus Lovenia Desor, 1847

Description: Test low, oval to heart-shaped, with subanal and internal fascioles; three or four gonopores; spheridia housed in cysts surrounding peristome; in some species primary tubercles of paired ambulacral areas recessed into camellae.

Florida species: L. clarki (Lambert, 1924).

Comments: The species is present in the Chattahoochee Formation. Thus far, only the Jim Woodruff Dam locality in northern Florida has been reported to have these fossils, but they are relatively common and moderately preserved at this site as external and internal molds.

Lovenia clarki (Lambert, 1924)
(Figure 3-18, E-H)

Material examined: UF 61083 (figured internal and external molds with RTV silicone rubber peels), UF 66934 through 66939 (one internal mold each).

Description: Test cordate, depressed, truncated behind. Known only as molds, which show cross-shaped petals, evidently terminated apically by an apical fasciole.

Pliocene Echinoids

Order Cidaroida Claus, 1880
Genus Eucidaris Pomel, 1883

Description: Like Stylocidaris but madreporite slightly larger than other genital plates; primary spines typically cylindrical, truncate, otherwise fusiform or

clavate; shaft abruptly truncate, terminating in crown with central prominence, and with low, rounded warts disposed in regular, longitudinal series; secondary spines adpressed; tridentate pedicellariae of two types, valves either straight or curved.

Florida species: E. tribuloides (Lamarck, 1816).

Comments: The species occurs in the Tamiami Formation in southwestern Florida (see Portell and Oyen, 1997, for detailed discussion).

Eucidaris tribuloides (Lamarck, 1816)
(Figure 3-19, A-B)

Material examined: UF 72022 (figured test), UF 60203 (test), UF 80300 (radiole), UF 68891 (test with spines), UF 62735 (35 radioles).

Description: Apical system subcircular or subpentagonal, easily detached, less than half the horizontal diameter. Periproct pentagonal, covered with polygonal plates. Peristome circular, nearly half the horizontal diameter, covered with imbricating plates. Ambulacra nearly straight; poriferous zones narrower than the interporiferous zones; zygopores slightly oblique, pores separated by a projecting wall; interporiferous zones bordered on each side by a row of imperforate miliary tubercles interspersed with small granules. Interambulacra composed of five to twelve tiers of plates. Each plate supports on its outer edge one large raised perforated tubercle surrounded by a ring of imperforate miliary tubercles; median part covered by transverse rows of smaller imperforate miliary tubercles. Primary tubercles supporting long, rather thick, cylindrical spines decorated with longitudinal rows of circular nodes; miliary

circles bearing short, flat, ribbed spines; other miliary tubercles bearing shorter, narrower, flat spines.

Order Arbacioida Gregory, 1900
Family Arbaciidae Gray, 1855
Genus Arbacia Gray, 1835

Description: Test low hemispherical or subconical, flattened adorally, of medium size. Ambulacra with trigeminate plates, pore zones straight, narrow above ambitus, conspicuously widened adorally. Primary ambulacra tubercles in regular series. Interambulacra with numerous primary tubercles in horizontal and vertical series. No secondary tubercles. Adapically interambulacra have conspicuous naked spaces.

Florida species: A. improcera (Conrad, 1843) and a second possible Arbacia sp.

Comments: Collected from the Tamiami and Jackson Bluff formations. Occurrence in the Jackson Bluff Formation represents new stratigraphic record, while the Arbacia sp. represents a new taxonomic record when it is formally described in the future. Due to the poor preservation of this fossil, it is very difficult to determine its specific status at the current time.

Arbacia improcera (Conrad, 1843)
(Figure 3-19, C)

Material examined: UF 83420 (figured test), UF 21399 (test with spines), UF 30406 (test), UF 47129 (test).

Description: Test large, horizontal outline circular; upper surface significantly depressed; lower surface evenly rounded and concave. Apical system dicyclic; plates covered with elongated granules; ocular plates having one high imperforate tubercle. Ambulacra narrow, regularly expanding to the ambitus, maintaining nearly the maximum width to the peristome; poriferous zones straight on upper surface, expanding near the peristome because of the increasing inclination of the groups of three zygopores; one spheridial pit in the middle of each area near the peristome. Interambulacral plates nearly three times as wide as high, tubercle-free areas covered by coarse, elongate granules. Periproct rather large, oblique. Tubercles high, imperforate; largest on margin and lower surface; two rows in each ambulacrum, becoming obsolete toward the apex; four rows on and below the ambitus in each interambulacrum, only the outer rows, much reduced in size, continuing to the apex. Peristome large, subpentagonal.

<u>Arbacia</u> sp.
(Figure 3-19, D-E)

Material examined: UF 7506 (figured test, nearly complete, although partially obscured by epitaxial cement and matrix).

Formation: Jackson Bluff Formation.

Locality: Jackson Bluff 02 (LN002), Leon County, Florida, Bloxham Quadrangle, Sec. 16, SW 1/4, T1S, R4W.

Collector: N. Weisbord.

Date: Unknown.

Description: Test small; diameter approximate 17 mm; horizontal outline circular and upper surface flattened to only slightly domed; apical system plates missing; adoral surface shows evidence of concavity toward peristome, but most of surface covered with tightly cemented matrix. Ambulacra relatively straight, narrow, expanding evenly to ambitus; zygopores possibly nonconjugate. Interambulacral plates approximately two to three times as wide as tall. Tubercles small, in two rows in interambulacrum, slightly increasing in size at ambitus and adoral surface; one to two additional rows of tubercles present at ambitus and below. Periproct absent (due to diagenetic compaction); peristome not visible (covered by matrix).

Comments: This fossil compares reasonably well with the characteristics of Arbacia, but the specific identification has not been determined yet. Based on the characteristics listed above, it appears to be different from another Florida species, A. improcera. However, it may be more closely related to an extant species, A. punctulata (Lamarck, 1816), than other described fossil species. Unfortunately, only one specimen has been collected thus far and it is not preserved well enough to allow identification with certainty.

Arbacia sp. cf. A. improcera (Conrad, 1843)
(Figure 3-19, F)

Material examined: UF 7507 (figured test fragment).

Formation: Jackson Bluff Formation.

Locality: Jackson Bluff 02 (LN002), Leon County, Florida, Bloxham Quadrangle, Sec. 16, SW 1/4, T1S, R4W.

Collector: N. Weisbord.

Date: Unknown.

Description: Test incomplete, with diameter estimated at 35-40 mm; horizontal outline likely circular and upper surface moderately arched. Ambulacra straight, reaching maximum width at ambitus; pore pairs closely spaced, conjugate, circular in outline. Interambulacral plates approximately three times as wide as tall; non-granular near apex. Tubercles largest at ambitus and below, decreasing in size adapically; distribution somewhat irregular moving toward apical system, more abundant at ambitus and lower surface. Periproct and peristome not present on test fragment.

Comments: The test is significantly fragmented and incomplete (estimated to be only 30% of original total), thereby limiting interpretations and identification. Preservation of the remaining material is very good. This specimen is different from the other regular echinoid (which I refer to as Arbacia sp.) reported herein from the Jackson Bluff Formation, and therefore the number of taxa from this unit reflects this interpretation. One of the closest matches for this fossil is another Pliocene species, A. improcera, that is present in the Tamiami Formation in Florida. Since the identification is tentative, this fossil does not represent a new taxonomic record for the Pliocene but is a new stratigraphic record of the genus for the Jackson Bluff Formation, regardless of specific identification.

cf. Arbacia sp.
(Figure 3-19, G)

Material examined: UF 84283 (figured test fragment).

Formation: Nashua Formation.

Locality: Cracker Swamp Ranch 01 (PU004); Putnam County, FL; Hastings Quadrangle, SE1/4, SW1/4, Sec. 24, T9S, R27E.

Collectors: R. Portell and C. Oyen.

Date: 6/26/96.

Description: Test fragment small, approximately 18 mm by 12 mm. Interpreted shell shape subhemispherical, curving moderately at ambitus. Tubercles largest at ambitus, becoming distinctly smaller adapically; tubercles with large boss and globose mamelon, scrobiculate with well-defined scrobicular ring. Poriferous zone consisting of two nearly straight columns of zygopores; three to four pore pairs per ambulacral plate. Interambulacral plates becoming granular adapically. Ambulacral areas approximately two thirds as wide as interambulacral regions.

Comments: The test fragment was derived from the ambitus of the original echinoid. Using the tubercle size and distribution in this area as a primary morphology guide, I interpret this pattern as similar to species of Arbacia. Therefore, I refer to this specimen as cf. Arbacia sp., and include it as a new stratigraphic record of the genus from the Nashua Formation but do not include it as a new taxonomic record or as a unique species for the Pliocene diversity count.

Order Temnopleuroida Mortensen, 1942
Family Toxopheustidae Troschel, 1872
Genus Lytechinus A. Agassiz, 1863

Description: Medium-sized to large, low hemispherical. Ambulacra plates trigeminate, each with primary tubercle; secondary ambulacra tubercles not in regular series; conspicuous naked median space aborally in both areas. Buccal membrane bearing numerous plates, in addition to oral plates.

Florida species: L. variegatus plurituberculatus Kier, 1963.

Comments: This fossil is present in the Tamiami and Caloosahatchee formations in southern Florida.

Lytechinus variegatus plurituberculatus Kier, 1963
(Figure 3-19, H-I)

Material examined: UF 12895 (figured test), UF 25764 (test), UF 30732 (test), UF 62805 (test fragment), UF 64825 (test).

Description: Test hemispherical, large. Apical system with serrate outline; the two posterior ocular plates insert. Periproct large, oval, eccentric. Ambulacra wide, trigeminate, the upper two zygopores of each plate near the outer edge, the lower one near the tubercle; zygopores forming a continuous row along the peristome in each ambulacrum. Plates much wider than high near the ambitus. Tubercles smooth, imperforate; two continuous rows in each area, passing through the center of each plate; additional rows in the interambulacra not reaching the apex, leaving bare median areas. Peristome subpentagonal; about one-third the total diameter; gill slits deep. Spines rather short, tapering,

longitudinally ribbed. Distinguished from nominate subspecies by more numerous tubercles in ambulacra.

Family Echinometridae Gray, 1825
Genus Echinometra Gray, 1825

Description: Ambitus oblong or elliptical, longer transverse axis passing through ocular I and genital 3; ambulacral plates polyporous, quadrageminate to decageminate, exceptionally trigeminate; spines equal to or shorter than test diameter, acuminate but not otherwise modified.

Florida species: E. lucunter (Linnaeus, 1758).

Comments: The species is present in the Caloosahatchee Formation of southern Florida. Fossils consist of test fragments and spines.

Echinometra lucunter (Linnaeus, 1758)
(Figure 3-19, J-K)

Material examined: UF 12937 (figured test), UF 27516 (test), UF 64824 (test).

Description: Horizontal outline obliquely elliptical or subpentagonal; variably inflated; ambitus broadly rounded. Apical system rather large; one or more ocular plates insert or not; madreporite swollen. Periproct oval, slightly eccentric. Ambulacra regularly expanding to the ambitus, about equal in width to the interambulacra at the peristome; zygopores arranged in disconnected arcs of six, more or less, except near the peristome, where they lie in straight, oblique

lines. Peristome nearly circular, weakly notched. Primary tubercles large, smooth, imperforate; in two rows on each area, largest on the interambulacra.

Order Clypeasteroida A. Agassiz, 1872
Family Clypeasteridae L. Agassiz, 1835
Genus Clypeaster Lamarck, 1801

Description: See Oligocene echinoid section for generic description.

Florida species: Up to seven species have been collected in the state, including C. crassus Kier, 1963, C. rosaceus dalli (Twitchell, 1915), C. subdepressus (Gray, 1825), C. sunnilandensis Kier, 1963, and three possible new species referred to herein as Clypeaster sp.

Comments: The species C. crassus, C. sunnilandensis, and Clypeaster sp. are present in the Tamiami Formation. The species C. rosaceus dalli and C. subdepressus are present in the Caloosahatchee Formation. The second unidentified species of Clypeaster is present in the Intracoastal Formation, which is a new stratigraphic record of the genus from the Intracoastal. The final unidentified species of Clypeaster is present in the Nashua Formation. This occurrence is a new stratigraphic record of the genus in the Nashua. Each Clypeaster sp. groups is a potential new taxonomic record for the Pliocene as well.

Clypeaster crassus Kier, 1963

Material examined: None available for examination in the FLMNH collection.

Description: Average test width 90 percent of length, average height 19 percent of length; test pentagonal with truncated posterior margin, pointed anterior with greatest width anterior to center; strong indentations in interambulacra 1, 4, 5; margin thick, 10 percent of length, area between margin and ends of petals flat or slightly depressed; petaloid area inflated; adoral surface flat. Apical system slightly posterior to center, five genital pores, small ocular plates, madreporite star-shaped. Petals broad, short, extending three-fifths distance from apical system to margin; anterior petal (III) slightly longer than others, anterior paired petals (II, IV) shortest, posterior paired petals (V, I) intermediate; interporiferous zone approximately twice width of poriferous zone; approximately 60 pore pairs in each poriferous zone. Periproct inframarginal, located near posterior margin; opening irregular in outline, elongated transversely. Peristome central to slightly posterior, pentagonal, pointed anteriorly, truncated posteriorly. Plate sutures of basicoronal plates not visible on all plates; basicoronal interambulacral plates separated from postbasicoronal plates by two pairs of ambulacral plates; seven to eight ambulacral, three to five interambulacral postbasicoronal plates in each series on adoral surface. Species characterized by thick margin and marginally indented interambulacra.

Clypeaster sunnilandensis Kier, 1963
(Figure 3-20, A-B)

Material examined: UF 22148 (figured test).

Description: Fossils large; test elongate, average width 85 percent of length; marginal outline pentagonal, anterior pointed, posterior truncated,

interambulacra 4 and 1 slightly indented at margin; area between margin and ends of petals sloping marginally; test low, average height 20 percent of length; margin thin, thickness approximately seven percent of length; petaloid area inflated, adoral surface slightly depressed. Apical system central to slightly anterior, five genital pores, small ocular plates, madreporite star-shaped. Petals broad, of unequal length, anterior petal (III) longest, 20 percent longer than anterior paired petals (II, IV); posterior paired petals intermediate in length; anterior petal open, gap at distal end of petal 4.4 percent of length, posterior petals open in some specimens; interporiferous zone approximately twice width of poriferous zone. Periproct inframarginal, located near posterior margin, opening irregular in outline, elongated transversely. Peristome central. Plate sutures not visible on any specimens. Species characterized by thick margin and marginally indented interambulacra.

<u>Clypeaster</u> <u>rosaceus</u> <u>dalli</u> (Twitchell, 1915)
(Figure 3-21, A-B)

Material examined: UF 65813 (figured test), UF 62796 (2 tests), UF 62797 (2 tests).

Description: Test large; pentagonal in marginal outline, longer than broad, broadest opposite the ends of the anterior petals, pointed anteriorly, posterior end truncated centrally; upper surface irregularly convex, high, highest back of center, whence sloping gently and in a straight line to the blunt, tumid anterior edge and quite steeply and in a straight line to the thinner, wedge-shaped posterior edge; under surface deeply concave, the concavity beginning

near the margin and increasing at first gradually then rapidly to the center. Ambulacral petals large, broad, very tumid, almost reaching the margin, nearly closing, the posterior pair slightly longer than the odd petal which is slightly longer than the anterior pair. Apical system central, sloping downward anteriorly; five genital pores a short distance from the slightly depressed madreporite. Peristome large, slightly eccentric posteriorly, subpentagonal, deeply sunken; ambulacral furrows simple, straight, reaching the margin. Periproct rather large, subcircular; inframarginal, almost marginal.

Clypeaster subdepressus (Gray, 1825)
(Figure 3-22, A-C)

Material examined: UF 98692 (figured test), UF 21532 (figured Recent test), UF 49994 (test), UF 49995 (test), UF 67249 (test).

Description: Test large; horizontal outline subovate to subpentagonal, usually truncate or reentrant in the interambulacra; upper surface tumid in the petaloidal region, flatter marginally; lower surface nearly flat, slightly concave at the peristome, having narrow ambulacral furrows, the paired furrows bent towards each other near the peristome; margin rather thin. Apical system pentagonal, with five genital pores at the corners of the madreporite. Petals rather short, extending more than halfway to the margin, the anterior the longest; poriferous zones curved inward at the outer tips but more or less open, pores near the apex inconspicuous, thereby seemingly wide open; interporiferous zones wide; pores conjugate. Peristome central, circular. Periproct near the posterior margin. Tubercles small.

Clypeaster sp.
(Figure 3-23, A)

Material examined: UF 104521 (figured incomplete test).

Formation: Intracoastal Formation.

Locality: Pickett Bay 01 (FR001); Franklin County, FL; Pickett Bay Quadrangle, NW1/4, NW1/4, Sec. 34, T6S, R5W.

Collectors: R. Portell and K. Schindler.

Date: 5/6/93.

Description: Horizontal outline pentagonal, gently rounded at anterior point; test margin medium to thin, rounded; test medium to large in dimension. Aboral surface covered with tightly cemented matrix and not visible. Adoral surface nearly flat, with minor concavity toward peristome; narrow, straight ambulacral furrows from margin to peristome. Peristome small, circular, located slightly posterior of center. Periproct circular to subcircular, small, near posterior margin. Tubercles small, uniformly distributed across test.

Comments: Only the adoral surface is visible in the described specimen, thus limiting full identification. The aboral surface is heavily coated with strongly cemented matrix, and this preservation style (i.e., surficially cemented matrix) affects most of the samples associated with the Intracoastal Formation from this locality. As a result, most of the samples are very difficult to clean, prepare, and consequently identify. The general test size, shape, and oral surface characteristics are consistent with those of the genus Clypeaster and therefore I refer to this fossil as Clypeaster sp. A species from the Caloosahatchee Formation, C. subdepressus, has a similar morphology for the adoral surface, but

without the diagnostic characteristic of the aboral surface to compare, I have chosen to defer a specific identification until better fossils are recovered. This fossil is the first report of the genus from the Intracoastal Formation and therefore is counted as a new stratigraphic record from the formation, but is not included as an additional species in the total species diversity from the Pliocene epoch.

Clypeaster sp.
(Figure 3-23, B-E)

Material examined: UF 30870 (figured test fragment), UF 44202 (figured test fragment), UF 35666 (test fragment).

Formation: Tamiami Formation.

Locality: Richardson Road Shell Pit 01 (SO019), Sarasota County, FL; Bee Ridge Quadrangle, Sec. 7/8, T36S, R19E; Phase 1 in pit, spoil samples (both UF 35666 and UF 30870). Macasphalt Shell Pit (SO001), Sarasota County, FL; Bee Ridge Quadrangle, E 1/2, Sec. 12, T36S, R18E; spoil sample (UF 44202).

Collectors: R. Portell (UF 30870), D. Bryant (UF 44202), and K. Schindler (UF 35666).

Date: 8/19/89, 3/21/87, 12/08/90, respectively.

Description: Only three test fragments total have been collected and were used for this description. Test margin broadly rounded. Test thins toward margin and gently thickens adapically. Plates thick in cross-section. Tubercles small, closely spaced, and densely distributed both on adoral and aboral surfaces. No diagnostic morphological features, including peristome, periproct,

zygopores, gonopores, apical system, petaloid ambulacra, present in these fossil fragments. Modest food groove furrow noted on adoral surface of one fossil. Test thickness at margin ranges from approximately four to seven mm.

Comments: Although only limited fragments of this echinoid taxon have been collected to date, identification to generic level is reasonably valid. The overall shape of the test margin, its thickness, and the tubercle density tends to support the identification as Clypeaster sp. Several species of Clypeaster have been reported from the Pliocene in Florida, and it is possible the fragments may be from disarticulated C. subdepressus, C. crassus, or C. sunnilandensis individuals. One slight morphological characteristic preserved in one of the fragments is the presence of a small furrow tracing the food groove and extending to near the test margin. Such a furrow is present in C. subdepressus, and may help in more clearly delineating the species as work continues. A more complete fragment or an unbroken individual will be required to interpret with certainty the taxonomic identification of these fossils from the Tamiami Formation.

Family Mellitidae Stefanini, 1911
Genus Encope L. Agassiz, 1840

Description: Apical system and peristome slightly anterior; posterior petals longest; posterior interambulacrum continuous; posterior lunule more than half inside line connecting ends of petals.

Florida species: Up to five taxa are present, including E. aberrans Martens, 1867, E. aberrans imperforata Kier, 1963, E. tamiamiensis Mansfield, 1932, and two possible varieties of Encope sp. from different strata and localities.

Comments: Fossils of E. aberrans are present in three formations in the state, including the Tamiami, Caloosahatchee, and Intracoastal formations. This is the first stratigraphic record of the species in the Intracoastal Formation. The subspecies E. aberrans imperforata is present in both the Tamiami and Caloosahatchee formations. Encope tamiamiensis is present in the Tamiami Formation in southern Florida, one of the Encope sp. records is from the Tamiami Formation (a new occurrence from Pinecrest Bed unit), the second Encope sp. is present in the Nashua Formation, and the final species is present in the Jackson Bluff Formation. The fossils from the Nashua Formation are new stratigraphic records from the unit, while all three Encope sp. references are possible new taxonomic records for the state. Preservation typically is poor for all representatives from the three Encope sp. localities, with most specimens observed as highly fragmented tests.

Encope aberrans Martens, 1867
(Figure 3-24, A-C and Figure 3-25, A-B)

Material examined: UF 104520 (figured test), UF 104519 (figured test), UF 104518 (figured test), UF 21531 (figured Recent test), UF 104517 (test), UF 67248 (2 Recent tests).

Description: Test spade shaped, longer than wide, highest behind the apical center, lower surface flat. Typically only two posterior ambulacral notches

and a lunule, with the three anterior ambulacra only slightly indented. Apical system central, star shaped, with five genital pores. Petals broadly lanceolate, open; poriferous zones wide, pores conjugate; inner pores circular, larger than the outer pores, which tend to enlarge along the conjugations. Peristome small, central, circular, with five pairs of buccal tubes. Periproct oval, within the first postbasicoronal plates; covered with moveable plates.

<u>Encope</u> <u>aberrans</u> <u>imperforata</u> Kier, 1963
(Figure 3-26, A-B)

Material examined: UF 56643 (figured test).

Description: Test broad with width varying from 94 to 101 percent of length; test very low varying from 7 to 12 percent of length; greatest width posterior to center, anterior margin rounded, posterior sharply truncated; greatest height posterior to center; ambulacral notches well developed on some specimens, absent on others; posterior closed interambulacral lunule present in some specimens thereby preserving area where it would occur, irregularly developed, in some specimens opening very small, in others quite large, usually irregular in shape, unsymmetrical; in few specimens no lunule; adoral surface flat to slightly depressed except for slight elevation between peristome and periproct; margin sharp. Apical system slightly anterior, madreporite large, star shaped, five genital pores, with genital pore 5 eccentric to right on most specimens. Ambulacral petals broad, closing distally, interporiferous zone wider in petal III than in other petals; anterior petal III, posterior paired petals (V and I) of approximately same length; anterior paired petals shorter than others, in most

specimens petal II shorter than petal IV. Adoral plate sutures not visible. Periproct opening longitudinal, located one-third distance from peristome to posterior margin. Peristome located central and circular in shape. This subspecies is similar in all respects to the nominate subspecies except that its posterior closed lunule is quite small or entirely absent.

Material examined: UF 8619 (figured test), UF 28217 (140 tests), UF 29685 (169 tests).

Description: Horizontal outline subcircular, concavely truncated behind, with four large lateral ambulacral notches and a weaker anterior notch, and a rather small posterior lunule; upper surface nearly flat, highest at the front end of the lunule; lower surface flat; margin rather thin. Apical system slightly anterior, with a large central star-shaped madreporite and five genital pores. The three anterior petals lanceolate, extending about two-thirds of the radius, equal; the posterior petals longer, curved around the lunule; poriferous zones open, inner pores circular, outer pores elongated, pores conjugate. Peristome slightly anterior, subcircular. Periproct near the lunule, smaller than the peristome. Lunule oval. Food grooves bifurcating near the peristome, branches slightly diverging, nearly straight, obscure lateral branches near the outer ends. Test is usually wider than long, rather thin, but not sharp at edges.

<u>Encope</u> sp. cf. <u>E</u>. <u>aberrans</u> Martens, 1867
(Figure 3-27, C-D and Figure 3-28, A)

Material examined: UF 104523 (figured test), UF 104524 (figured test in matrix).

Formation: Nashua Formation.

Locality: Cracker Swamp Ranch 01 (PU004); Putnam County, FL; Hastings Quadrangle, SE1/4, SW1/4, Sec. 24, T9S, R27E.

Collectors: R. Portell and C. Oyen

Date: 7/9/96 and 7/21/96.

Description: Test medium size; horizontal outline broadly arcing at anterior, widest slightly posterior of center, and truncated at posterior margin in interambulacrum 5. Aboral surface gently sloping away from highest point posterior of apical system toward margins; margins medium to thin and rounded; adoral surface slightly concave from margins toward peristome. Petals large, broadly lanceolate, curving nearly closed at distal ends; petals extend approximately 85 percent of distance to margin. Apical system at center to slightly eccentric anteriorly. Test margin with slight notches at ambulacra II, III, and IV; more extensive notches at margins of ambulacra I and IV; all ambulacral notches much wider at distal end than at adapical end. Posterior lunule small to medium; width proportionally larger thereby producing an elliptical shape. Peristome small, circular, located centrally.

Comments: The fossils collected from this locality most commonly are fragmented and show evidence of significant weathering. Several echinoids have been discovered in the sediment within bivalves, and they tend to have much better preservation and are more complete. Examination of these fossils provided the information for the description above, and allows the tentative identification of <u>Encope</u> sp. cf. <u>E</u>. <u>aberrans</u> Martens, 1867. This somewhat

unusual preservation style (echinoids preserved within articulated or isolated bivalve shells) is not unique to the Cracker Swamp Ranch locality or the Nashua Formation, and similar examples of this preservation have been noted in other stratigraphic units (dominantly Neogene strata). In summary, these fossils are counted as new stratigraphic records for the Nashua Formation, but are not counted as a new taxonomic record or an additional species for the diversity summary of the Pliocene.

cf. Encope sp.
(Figure 3-28, B-E)

Material examined: UF 7501 (figured two test fragments), UF 7107 (13 test fragments), UF 7159 (50 test fragments), UF 79405 (test fragment).

Formation: Jackson Bluff Formation.

Locality: Jackson Bluff 02; Leon County, FL; 1 mile west of Bloxham, FL; Bloxham Quadrangle, SW 1/4, Sec. 16, T1S, R4W; and Jackson Bluff 01 (LN001); Leon County, FL; Bloxham Quadrangle, NW 1/4, Sec. 21, T1S, R4W

Collectors: N. Weisbord (UF 7107, 7159, 7501) and H.K. Brooks (UF 79405).

Date: Unknown (Weisbord); 1959 (Brooks).

Description: Only small fragments of test were available for examination. Test margin ranges from thinly rounded to broadly rounded, depending on fragment examined. Adoral and aboral surfaces relatively flat near margin; some evidence for gently increasing slope on aboral surface in petaloid region. Petaloid ambulacra potentially broad, lanceolate, and closed at distal end

(though no complete petals are present in samples). At least one fragment shows evidence of an ambulacral notch or lunule, though incomplete. Tubercles very small, tightly spaced, and uniformly distributed on plates. No remnants of apical system, gonopores, zygopores, peristome, or periproct on fossils collected thus far. Test thickness at margin ranges from approximately two to seven mm.

Comments: These fossils are difficult to identify due the highly fragmented nature of the specimens. Most test fragments also are significantly weathered deeply enough to expose the stereom, thereby eliminating food grooves and most tubercles on the specimens. However, identification to the family Mellitidae is reasonable, and based on test margin thickness and potential ambulacral invaginations or lunules, I believe these most likely are fragments from a species of Encope. Unfortunately, it is not possible to refine the identifications until larger, more complete fragments or entire specimens are found. These fossils are significant in my study because they are the first stratigraphic record of Encope, or any mellitids, from the Jackson Bluff Formation.

Genus Mellita L. Agassiz, 1841

Description: Thin, flattened, ambitus sharp; paired ambulacral lunules only; lunules narrow, elongate, normally closed; anterior paired petals shortest, others about equal; peristome and apical system slightly anterior; four genital pores; posterior interambulacrum continuous.

Florida species: M. aclinensis Kier, 1963 and Mellita sp. cf. M. caroliniana (Ravenel, 1841).

Comments: The species M. aclinensis is present in the Tamiami Formation, while the Mellita sp. is present in the Nashua Formation. The fossils of M. aclinensis are extremely abundant in localized areas and are indicative of the Tamiami Formation. The recently collected Mellita sp. cf. M. caroliniana from the Nashua represents a new stratigraphic record for the formation, and when better preserved specimens are found they may turn out to be new taxonomic records too.

Mellita aclinensis Kier, 1963
(Figure 3-29, A-B)

Material examined: UF 28207 (figured test), UF 40359 – 40370 (one test each).

Description: Test margin subcircular except for truncated posterior margin on some specimens; width approximately equal to length; test very low with thin sharp margin; adoral surface flat to slightly concave; five elongate ambulacral lunules in large specimens, lunule in ambulacrum III smaller than others; lunule in posterior interambulacrum very elongate, extending far between petals. Apical system slightly anterior, distance from anterior margin to apical system approximately 45 percent of length of test; large madreporite; four genital pores. Anterior petals II, III, IV lanceolate, straight, petal III longer, extending almost two-thirds distance from apical system to anterior margin, petals II and IV only halfway to margin; curving posteriorly; in all petals poriferous zone equal in

width to interporiferous; petals almost closed. Adorally, five pairs of food grooves extending from peristome to near margin; area circumscribed by pair of grooves expanding distally with greatest width near lunule, constricted distal to lunule; area broad between adjacent pairs of grooves. Secondary pores difficult to see in most specimens, apparently confined to area circumscribed by food grooves. Periproct opening small, elongate, located at anterior edge of lunule. Peristome anterior, small, subcircular to pentagonal, food grooves bifurcating near peristome. Basicoronal plates small; adoral-most plate of interambulacrum 5 considerably larger than other basicoronal plates; paired interambulacra separated from basicoronal plates by one pair of ambulacral plates, three postbasicoronal plates in each column on adoral surface; first pair of postbasicoronal interambulacral plates elongate; posterior interambulacrum in contact with basicoronal plates; half of periproct within basicoronal interambulacrum extending length of lunule. Species characterized by five ambulacral lunules.

Mellita sp. cf. M. caroliniana (Ravenel, 1841)
(Figure 3-29, C-D)

Material examined: UF 104526 (figured test in matrix), UF 104527 (figured test in matrix).

Formation: Nashua Formation.

Locality: Cracker Swamp Ranch 01 (PU004); Putnam County, FL; Hastings Quadrangle, SE1/4, SW1/4, Sec. 24, T9S, R27E.

Collectors: R. Portell and C. Oyen.

Date: 6/25/96.

Description: Horizontal outline subcircular; widest at approximate midpoint to slightly posterior of test. Adoral surface flat; peristome near center; aboral surface nearly flat with gentle slope away from apical system. Test margin narrowed, varying from pointed to tightly curved. Petals incompletely preserved, but lanceolate, nearly closed at distal end; estimated to be approximately half the distance to margin, terminating adapically from ambulacral lunules; zygopores elliptical, widely spaced, conjugate, with outer pore positioned preferentially toward margin. Ambulacral lunules present in each ambulacrum; short, oval-shaped; one proportionally larger lunule posterior of periproct in inter-mbulacrum 5; narrower than ambulacral lunules. Apical system not preserved in specimens. Tubercles small, closely spaced; rarely preserved due to weathering.

Comments: Weathering and post-mortem transport have left most specimens from this locality fragmented and incomplete. The best preserved specimens all have been prepared from sediment trapped within large bivalve shells (see Figure 3-29, C-D), and these fossils provide the best overall views of their morphology. These sand dollars are tentatively identified as <u>Mellita</u> sp. cf. <u>M</u>. <u>caroliniana</u> based on the test outline, small ovate ambulacral lunules (five total), and the proportionally short petaloid ambulacra. This is the first report of <u>M</u>. <u>caroliniana</u> from the Nashua Formation, and I have included these fossils as new stratigraphic records for the Pliocene as well as in the total diversity count for the epoch. Once specimens are collected which include a preserved apical

system, peristome, and periproct, comparisons can be completed for all morphological features and verification of the identification will be possible.

Genus Leodia Gray, 1852

Description: Like Mellita but with five closed ambulacral lunules.

Florida species: L. sexiesperforata (Leske, 1778).

Comments: This species is present in the Nashua Formation. Only two fossils have been collected, but they are important specimens. Controversy among fellow echinoid workers (zoologists versus paleontologists) leads to a tentative identification at this time. I have chosen to assign the fossils to the Leodia genus based on the ambulacral lunule arrangement and their overall size. The zoologist's interpretation is that they simply represent unusually large individuals of Mellita aclinensis or M. caroliniana, but I find this approach invalid based on the fossil M. aclinensis individuals I have sampled and measured. None of the hundreds of M. aclinensis fossils from Florida are close to the size of these specimens from the Nashua Formation, and therefore I believe the difference is real rather than a simple artifact. Continued collection and sampling from the Nashua may provide new specimens in the future, which can help solve the taxonomic problem associated with these fossils.

Leodia sexiesperforata (Leske, 1778)
(Figure 3-30, A)

Material examined: UF 31969 (figured test).

Description: Horizontal outline subcircular, flattened behind; upper surface nearly flat, highest at the anterior petal; lower surface flat. Apical system central; madreporite star shaped, with five sharp points; four genital pores outside the madreporite and detached from it. Petals short, less than half the radius, nearly equal in length, lanceolate; poriferous zones as wide as the interporiferous, inner pores oval, outer pores elongated, pores conjugate. All five ambulacra penetrated by a long, narrow, straight lunule between the petals and the margin; posterior lunule slightly wider, occupying the middle third of the radius. Peristome small, circular, central, with paired buccal tubes. Periproct small, pear-shaped, lying midway between the peristome and the lunule. Food grooves deep, narrow, perforated; divaricating at the peristome, each branch running parallel to that of the neighboring ambulacrum and branching several times near the margin. Spines short, straight.

Order Cassiduloida Claus, 1880
Family Cassidulidae L. Agassiz and Desor, 1847
Genus Rhyncholampas A. Agassiz, 1869

Description: See Oligocene echinoid section for generic description.

Florida species: Two species are found in the state, including R. ayresi Kier, 1963 and R. evergladensis (Mansfield, 1932).

Comments: The species R. evergladensis is present in the Tamiami Formation and R. ayresi is present in the Caloosahatchee Formation.

Rhyncholampas ayresi Kier, 1963
(Figure 3-30, B-C)

Material examined: UF 63062 (figured test), UF 63215 (test), UF 63368 (test), UF 63767 (test), UF 63770 (test).

Description: Test varying in length; test width approximately 85 to 90 percent of length with greatest width posterior of center; adapical surface highly inflated with steeply sloping sides, height averaging 55 percent of length; adoral surface flat or slightly depressed around peristome. Apical system anterior, four genital pores, compact. Petals well developed, broad, lanceolate, with greatest width one-third distance from apical system to end of petal, all petals of approximately equal length, petals II, IV wider than others, petal III narrower; poriferous zones of unequal length with one to three more pore pairs in right poriferous zone of petal II, posterior zones of petals II and IV, and anterior poriferous zones of petals V and I; single pores in ambulacral plates beyond petals. Periproct supramarginal, wider than high, with slight groove extending from opening to posterior margin. Peristome anterior, pentagonal, depressed, wider than high. Floscelle with phyllodes well developed, broad, approximately 30 pores in each phyllode, with 10 in each outer series, four to six irregularly arranged in each inner. Buccal pores present. Bourrelets very prominent, pointed. Tubercles adorally much larger than adapically, narrow naked granular zone in median area of interambulacrum 5 and ambulacrum III adorally. Species characterized by highly inflated adapical surface, steep sides, smooth marginal outline, narrow naked zone in interambulacrum 5, and narrow phyllode III.

Rhyncholampas evergladensis (Mansfield, 1932)
(Figure 3-31, A-B)

Material examined: UF 17312 (figured test), UF 20918 – 20925 (one test each lot), UF 34405 (test), UF 60126 (test).

Description: Test large, suborbicular, and moderately high; upper surface convex and broadly rounded, the posterior surface more gently inclined than the anterior; lower surface nearly flat except in the area surrounding the peristome, where it is shallowly concave. Apical system, situated opposite the peristome, is rather large, granular, and slightly elevated; a genital pore is at the juncture of the petals and a smaller radial pore is opposite each petal. Ambulacral areas petaloid at dorsal portions. Petals rather long, extending nearly to the ambitus, expanding to about one-third their length from the apical system, then gradually contracting distally, and nearly closing at their extremities; poriferous zones rather wide, shallowly depressed; pores nearly equal in size and rounded in outline; pairs of pores conjugate. Interporiferous areas weakly tumid. Posterior interambulacrum weakly medially arched. Periproct rather large, longest transversely; supramarginal, the lower margin being about four millimeters above the ambitus; the upper arched margin slightly overhangs the aperture. Peristome eccentric anteriorly, pentagonal, transversely elongate, and surrounded by a large well-defined floscelle with prominent bourrelets. The outer pores of the floscelle are more direct and more regularly placed; the inner ones are more irregularly placed and some of them are arranged in two rows. The surface of the test is closely set with scrobiculate tubercles.

Order Spatangoida Claus, 1876
Family Paleopneustidae A. Agassiz, 1904
Genus Pericosmus L. Agassiz, 1847

Description: Peripetalous fasciole passing above periproct and entirely separate marginal fasciole passing below periproct, peripetalous fasciole may branch anteriorly, and one or other fasciole may disappear anteriorly; apical system ethmolytic, with three or four gonopores; paired ambulacra having depressed petals which tend to have distal plates occluded.

Comments: One or possibly two species were collected from an undetermined stratigraphic unit in the Gulf of Mexico, and herein are referred to as Pericosmus spp.

Pericosmus spp.
(Figure 3-31, C-F and Figure 3-32, A-B)

Material examined: UF 101885 (figured partial, phosphatized test with nearly complete internal mold), UF 66566 (figured internal mold of test).

Formation: Uncertain.

Locality: Ocean floor samples, Gulf of Mexico. UF 101885 dredged from approximately 511 m, December 19, 1989 at OTB5 (27º 01'N, 84º 56'W) (UF locality 3784). The second fossil, UF 66566, dredged from approximately 520 m, May 4, 1993, at WFS1 (26º 56.29'N, 84º 55.75'W) (UF locality 3810).

Collectors: D. Hodell (UF 101885) and K. Fountain (UF 66566).

Date: 12/19/89 (UF 101885) and 5/4/93 (UF 66566).

Description: One fossil, UF 101885, test outline is subcircular, with maximum width slightly anterior of ambitus. Specimen somewhat compressed at

apical system, although overall shape is not distorted significantly. Unfortunately, this compaction and the remnant sediment cemented to the surface has inhibited identification of apical system morphology. Periproct and peristome are nearly intact and largely unaffected by diagenesis or fragmentation. Peristome has elevated labrum, and is located slightly anterior of the test center and distinctly posterior of the anterior sulcus termination on adoral surface. Anterior sulcus is modestly developed and approximately half as deep as it is wide. Adoral surface is generally flat while aboral surface originally was dome shaped (though presently collapsed). Test margins are broadly rounded. The anterior half of both adoral and aboral surfaces show well-preserved molds of tubercles, both large and small, and relict plate sutures are visible in various areas of the specimen. Ambulacrum I and IV petals are partially preserved, with pore-pairs present. Petals are closed, lanceolate, and terminate approximately midway between former apical system and ambitus. The second fossil, UF 66566, test outline subcircular to subpentagonal, with maximum test width located distinctly anterior of ambitus. All surfaces of this internal mold have been bored extensively, but the general shape of the test is preserved. Adoral surface relatively flat, with test margins broadly curved or rounded, and a gently domed aboral surface with a slight peak at the approximate apical system location. No ambulacra, plate sutures, tubercles, or other morphological traits are visible on the mold surfaces. Anterior sulcus is small to moderate in size, with sulcus length subequal in dimension to the sulcus width. Peristome visible on adoral surface, positioned distinctly anterior of test center and near the posterior margin

of sulcus. Peristome slightly curved and ovate, with elevated labrum. Periproct not preserved.

Comments: The UF 101885 specimen has undergone phosphatization, but it is apparent that the anterior portion of the test is intact while only the posterior portion is exclusively an internal mold of phosphatized carbonate sediment. Some micromorphology is visible, such as tubercles and pore-pairs (see description), and overall preservation is the best of the echinoids collected along the upper west Florida slope. Surface borings and epibionts are present, and are located principally on the aboral surface. The only significant preservational effect which limits complete description of the specimen is the slight compaction and collapse of the apical system.

Preservation quality of the second Pericosmus specimen (UF 66566) is better than that of the brissid (UF 57743; see below), but it is a more poorly preserved internal mold than the other Pericosmus sp. fossil (UF 101885); therefore, relatively few diagnostic morphological characteristics could be described. However, in addition to the traits of test length, width, and height, the shape and position of the peristome are evident. The adoral surface of UF 66566 (Figure 8A) is imperfectly preserved and bored, but adorally (Figure 8C) the mold provides a generally good surface for examination. Since the peristome shape and position commonly are used to aid in taxonomic descriptions, this specimen can be identified (tentatively) to generic level. Based on these discernable characteristics, the best placement for this specimen is also within the genus Pericosmus. Oyen et al. (2000) discuss these fossils in more detail.

The primary significance of these fossils is a function of their stratigraphic age and geographic distribution. Both fossil and extant species of Pericosmus are known from the Caribbean as well as from other parts of the world. Only three countries in the Caribbean and the Gulf of Mexico region, Cuba, Costa Rica, and Venezuela, have fossil records of this genus. All of the Cuban species were found in Eocene through Miocene age strata. The Venezuelan and Costa Rican species both were collected from the Miocene. Therefore, these specimens represent the youngest fossils of Pericosmus in the Caribbean and Gulf of Mexico. In addition, only one other record of a Pliocene species (i.e., P. schencki Israelsky, 1933 from the Malumbang Formation, Philippine Islands) has been published. Because the age of the Philippine fossil is very questionable, these upper west Florida slope fossils may provide a biostratigraphic range extension of the genus. Furthermore, if my identification is correct, this represents the first report of fossil Pericosmus from the United States.

Family Schizasteridae Lambert, 1905
Genus Agassizia L. Agassiz and Desor, 1847

Description: See Eocene echinoid section for generic description.

Florida species: A. porifera (Ravenel, 1848).

Comments: The species is present in the Caloosahatchee and Tamiami formations. The Tamiami Formation occurrence reported herein is a new stratigraphic record of the species that was collected from a pit in southwestern Florida.

Agassizia porifera (Ravenel, 1848)
(Figure 3-33, A-B)

Material examined: UF 12894 (figured test), UF 14144 (test), UF 22150 (test), UF 23973 (test), UF 24522 (test).

Description: Horizontal outline ovate, widest in front, truncated behind; upper surface strongly inflated to subconical, highest at the apical system, sloping steeply forward, less steeply to the posterior truncation; margin broadly rounded; lower surface gently inflated. Apical system nearly central; four genital pores, rather close together; ethmolytic, the madreporite extending beyond the posterior ocular pores. Anterior ambulacrum very slightly depressed, not at all depressed at the margin; pores obscure. Paired petals moderately depressed; long, the posterior pair somewhat shorter; anterior paired petals in line near the apex, curving gently forward to an angle of approximately 97º; posterior pair curving slightly outward to an angle of approximately 70º; pores of posterior petals and posterior zone of anterior pair very small and inconspicuous, pore pairs oblique; interporiferous zones narrow. Peristome at the anterior quarter, reniform; labium large. Periproct large, transversely elliptical; at the top of truncation, which is depressed. Plastron expanding for more than half its length, then sides curving inward. Marginal fasciole complete, curving downward below the periproct; hemipetalous fasciole indented in the posterior and postero-lateral interambulacra, meeting the marginal fasciole behind the anterior paired petals.

Family Brissidae Gray, 1855
Genus Plagiobrissus Pomel, 1883

Description: See Eocene echinoid section for generic description.

Florida species: P. grandis (Gmelin, 1791).

Comments: This species is present in the Tamiami Formation. It is a unique specimen that may represent the first fossil record of this species, and therefore it represents a new stratigraphic record for the species. Caution must be exercised with this fossil, however, due to the incomplete nature of the test.

Plagiobrissus grandis (Gmelin, 1791)
(Figure 3-33, C-E)

Material examined: UF 22152 (figured incomplete test), UF 5343 (Recent test).

Description: Test very large; horizontal outline suboval, truncated and somewhat emarginate in front; upper surface flat on top, steeply sloping at each end; lower surface gently convex; margin acutely rounded. Apical system slightly anterior; proportionately small; four genital pores; strongly ethmolytic, the madreporite extending far beyond the ocular plates. Anterior ambulacrum narrow, depressed; plates nearly equilateral; pore pairs small, longitudinal. Petals narrow, somewhat flexuous, depressed, extending more than two-thirds the way to the margin; anterior pair diverging at an angle of 100°, posterior pair, 37°; pores circular, strongly conjugate; interporiferous zones narrower. Ambulacra on lower surface very narrow; posterior pair nearly parallel. Peristome at the anterior quarter, semilunate; floscelle conspicuous. Paired interambulacra excluded from the peristome. Periproct submarginal, sloping upward and backward, not visible from above; longer than wide. Escutcheon semilunate, concave behind; surrounded by a wide subanal fasciole. Anal

fasciole broadly U-shaped, wider than high, branches extending about even with the upper end of the periproct. Peripetalous fasciole narrow, nearly oval. Tubercles of paired interambulacra large, perforated; confined within the peripetalous fasciole. Tubercles of posterior interambulacrum somewhat smaller, confined to median region but extending beyond the fasciole almost to the posterior end.

Family Brissidae Gray, 1855
Fam., gen., et sp. indet.
(Figure 3-34 A-C)

Material examined: UF 57743 (figured internal mold of test).

Formation: Uncertain.

Locality: Ocean floor sample, Gulf of Mexico. Dredged from approximately 511 m, at OTB8 (27º 05'N, 84º 57'W) (UF locality 3811).

Collector: K. Fountain.

Date: 12/19/89.

Description: Very limited morphological features are visible on this fossil, although the general test length, width, and height can be distinguished, as well as the slight sulcus along ambulacrum III.

Comments: Of the three echinoids recovered from the upper west Florida slope, this specimen is the most poorly preserved. The relative proportions of the test length, width, and height, the slight anterior sulcus, and the overall shape suggest a strong affinity to the Brissidae (see Oyen et al., 2000 for further discussions).

Family Loveniidae Lambert, 1905
Genus Echinocardium Gray, 1825

Description: Differs from typical loveniids in scarcity of large spines and tubercles, and absence of deep areoles or camellae; subanal fasciole with pair of anal branches.

Florida species: E. orthonotum (Conrad, 1843).

Comments: The species is present in the Tamiami, Jackson Bluff, and Intracoastal formations. This stratigraphic distribution includes a new stratigraphic record from the Intracoastal Formation of northern Florida. Readers should note that Kier (1963) originally reported this fossil in Florida as E. gothicum (Ravenel, 1848), which was an incorrect specific assignment on Kier's part. Also, the preservation of the Jackson Bluff specimen is poor, and my identification of the species should be considered only a preliminary identification.

Echinocardium orthonotum (Conrad, 1843)
(Figure 3-34, D-H)

Material examined: UF 60182 (figured test), UF 104522 (figured test), UF 62736 (5 test fragments), UF 62739 (test), UF 39540 (16 test fragments).

Description: Test ovate, convex-depressed; truncated at each end, more elevated anteriorly than posteriorly; dorsal line of the suture a little elevated, and curved gradually to the mouth on the anterior half; on the posterior, straight to the margin and parallel to the base; canal very wide and slightly impressed on the back, margined by an obtuse carinated line and slight furrow; on the periphery

Figure 3-19. Pliocene regular echinoids.

A) Eucidaris tribuloides (Lamarck, 1816); UF 72022; aboral view of flattened test; Tamiami Formation; 1x.

B) Eucidaris tribuloides (Lamarck, 1816); UF 72022; adoral view of flattened test showing partially exposed lantern; Tamiami Formation; 1x.

C) Arbacia improcera (Conrad, 1843); UF 83420; aboral view of test; Tamiami Formation; 1x.

D) Arbacia sp.; UF 7506; aboral view of test; Jackson Bluff Formation; 1x.

E) Arbacia sp.; UF 7506; adoral view of test; Jackson Bluff Formation; 1x.

F) Arbacia sp. cf. A. improcera (Conrad, 1843); UF 7507; aboral view of test fragment; Jackson Bluff Formation; 1x.

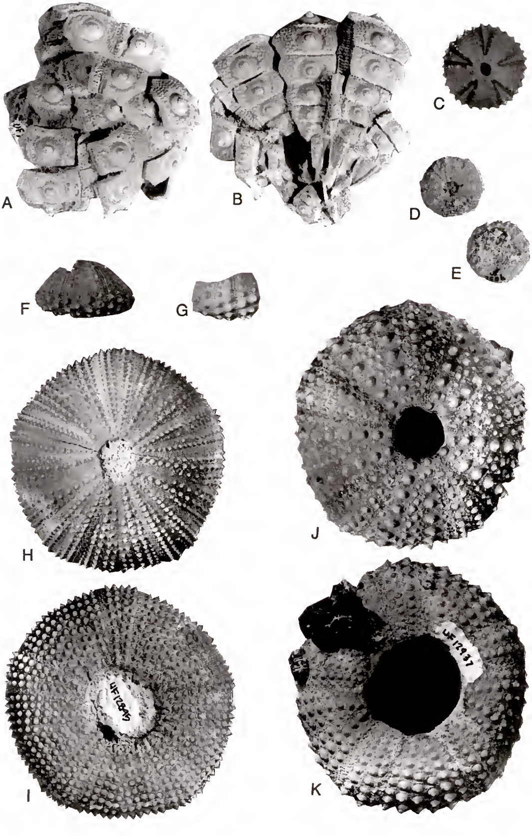
G) cf. Arbacia sp.; UF 84283; aboral view of test fragment; Nashua Formation; 1x.

H) Lytechinus variegatus plurituberculatus Kier, 1963; UF 12895; aboral view of test; Caloosahatchee Formation; 1x.

I) Lytechinus variegatus plurituberculatus Kier, 1963; UF 12895; adoral view of test; Caloosahatchee Formation; 1x.

J) Echinometra lucunter (Linnaeus, 1758); UF 12937; aboral view of test; Caloosahatchee Formation; 1x.

K) Echinometra lucunter (Linnaeus, 1758); UF 12937; adoral view of test; Caloosahatchee Formation; 1x.


A
B
C
D
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H
J
I
K

Figure 3-20. Pliocene irregular echinoids.

A) Clypeaster sunnilandensis Kier, 1963; UF 22148; aboral view of test; Tamiami Formation; 0.75x

B) Clypeaster sunnilandensis Kier, 1963; UF 22148; adoral view of test; Tamiami Formation; 0.75x

A

B

Figure 3-21. Pliocene irregular echinoids.

A) Clypeaster rosaceus dalli (Twitchell, 1915); UF 65813; aboral view of test; Caloosahatchee Formation; 0.75x.

B) Clypeaster rosaceus dalli (Twitchell, 1915); UF 65813; adoral view of test; Caloosahatchee Formation; 0.75x.

A

B

Figure 3-22. Pliocene irregular echinoids with Recent specimens for comparison.

A) Clypeaster subdepressus (Gray, 1825); UF 98692; aboral view of test; Tamiami Formation; 0.75x.

B) Clypeaster subdepressus (Gray, 1825); UF 21532, aboral view of Recent test; 0.5x.

C) Clypeaster subdepressus (Gray, 1825); UF 21532, adoral view of Recent test; 0.5x.

A

B

C

Figure 3-23. Pliocene irregular echinoids.

A) Clypeaster sp.; UF 104521; adoral view of incomplete test; Intracoastal Formation; 1x.

B) Clypeaster sp.; UF 30870; aboral view of test fragment; Tamiami Formation; 1x.

C) Clypeaster sp.; UF 30870; adoral view of test fragment; Tamiami Formation; 1x.

D) Clypeaster sp.; UF 44202; aboral view of test fragment; Tamiami Formation; 1x.

E) Clypeaster sp.; UF 44202; adoral view of test fragment; Tamiami Formation; 1x.

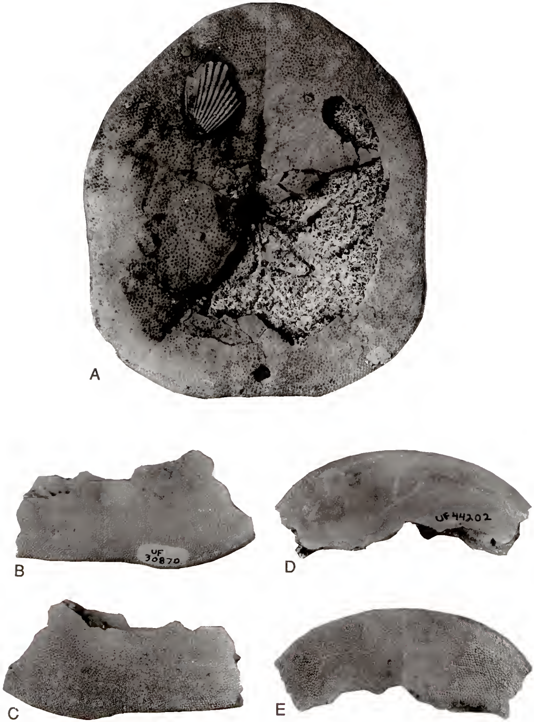

A
B
UF
30870
C
D
UF44202
E

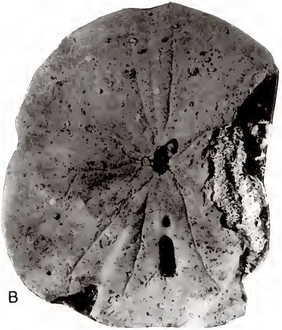
Figure 3-24. Pliocene irregular echinoids.

A) _Encope aberrans_ Martens, 1867; UF 104520, aboral view of test fragment; Intracoastal Formation; 0.57x.

B) _Encope aberrans_ Martens, 1867; UF 104519, adoral view of test; Intracoastal Formation; 0.75x.

C) _Encope aberrans_ Martens, 1867; UF 104518, adoral view of test; Intracoastal Formation; 0.75x.

A



B

C

Figure 3-25. Recent irregular echinoids for comparison purposes.
A) Encope aberrans Martens, 1867; UF 21531; aboral view of Recent test; 1x.
B) Encope aberrans Martens, 1867; UF 21531; adoral view of Recent test; 1x.

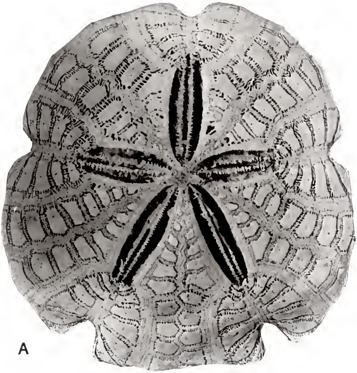
A

B

Figure 3-26. Pliocene irregular echinoids.

A) *Encope aberrans imperforata* Kier, 1963; UF 56643; aboral view of highly eroded test; Caloosahatchee Formation; 1x.

B) *Encope aberrans imperforata* Kier, 1963; UF 56643; adoral view of highly eroded test; Caloosahatchee Formation; 1x.



A

B

Figure 3-27. Pliocene irregular echinoids.

A) _Encope_ _tamiamiensis_ Mansfield, 1932; UF 8619; aboral view of test; Tamiami Formation; 1x.
B) _Encope_ _tamiamiensis_ Mansfield, 1932; UF 8619; adoral view of test; Tamiami Formation; 1x.
C) _Encope_ sp. cf. _E_. _aberrans_ Martens, 1867; UF 104523; aboral view of test; Nashua Formation; 1x.
D) _Encope_ sp. cf. _E_. _aberrans_ Martens, 1867; UF 104523; adoral view of test; Nashua Formation; 1x.


A
B
C
D

Figure 3-28. Pliocene irregular echinoids.

A) Encope sp. cf. E. aberrans Martens, 1867; UF 104524; aboral view of test; Nashua Formation; 1x.

B) cf. Encope sp.; UF 7501; test fragment; Jackson Bluff Formation; 1x.

C) cf. Encope sp.; UF 7501; test fragment; Jackson Bluff Formation; 1x.

D) cf. Encope sp.; UF 7501; test fragment; Jackson Bluff Formation; 1x.

E) cf. Encope sp.; UF 7501; test fragment; Jackson Bluff Formation; 1x.

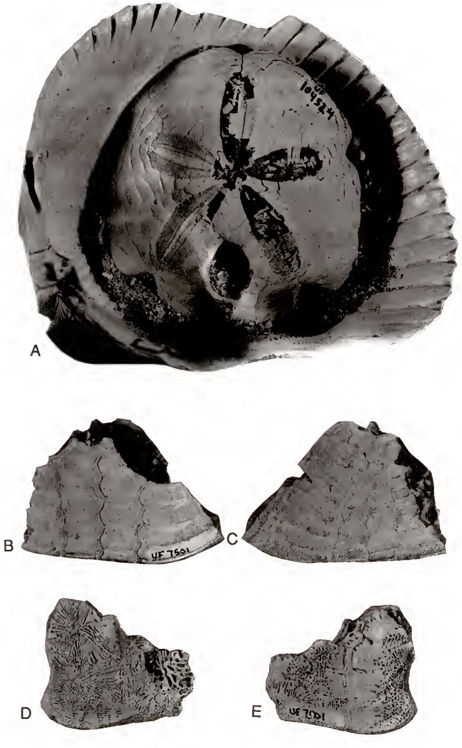

A
B
C
D
E

Figure 3-29. Pliocene irregular echinoids.

A) Mellita aclinensis Kier, 1963; UF 28207; aboral view of test; Tamiami Formation; 1x.

B) Mellita aclinensis Kier, 1963; UF 28207; adoral view of test; Nashua Formation; 1x.

C) Mellita sp. cf. M. caroliniana (Ravenel, 1841); UF 104526, adoral view of test; Nashua Formation; 0.63x;

D) Mellita sp. cf. M. caroliniana (Ravenel, 1841); UF 104527, adoral view of test; Nashua Formation; 0.65x

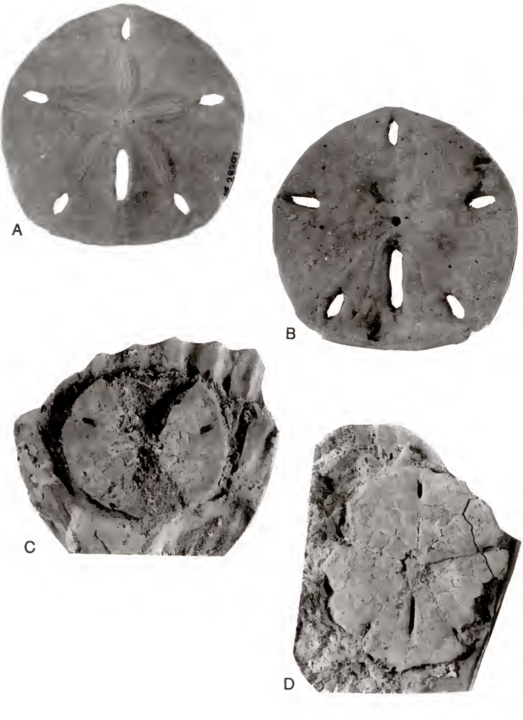

A
B
C
D

Figure 3-30. Pliocene irregular echinoids.

A) <u>Leodia</u> <u>sexiesperforata</u> (Leske, 1778); UF 31969; aboral view of test; Tamiami Formation; 0.75x

B) <u>Rhyncholampas</u> <u>ayresi</u> Kier, 1963; UF 63062; aboral view of test; Caloosahatchee Formation; 1x.

C) <u>Rhyncholampas</u> <u>ayresi</u> Kier, 1963; UF 63062; adoral view of test; Caloosahatchee Formation; 1x.

A

B

C

Figure 3-31. Pliocene irregular echinoids.

A) Rhyncholampas evergladensis (Mansfield, 1932); UF 17312; aboral view of test; Tamiami Formation; 1x.

B) Rhyncholampas evergladensis (Mansfield, 1932); UF 17312; adoral view of test; Tamiami Formation; 1x.

C) Pericosmus sp.; UF 101885; aboral view of phosphatized, partial test and internal mold; undetermined stratigraphic unit; 1x.

D) Pericosmus sp.; UF 101885; adoral view of phosphatized, partial test and internal mold; undetermined stratigraphic unit; 1x.

E) Pericosmus sp.; UF 101885; anterior view of phosphatized, partial test and internal mold with peristome visible; undetermined stratigraphic unit; 1x.

F) Pericosmus sp.; UF 101885; posterior view of phosphatized, partial test and internal mold with outline of periproct visible; undetermined stratigraphic unit; 1x.

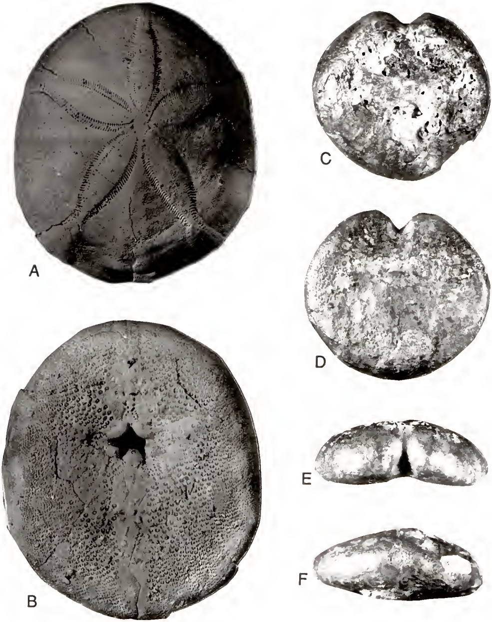
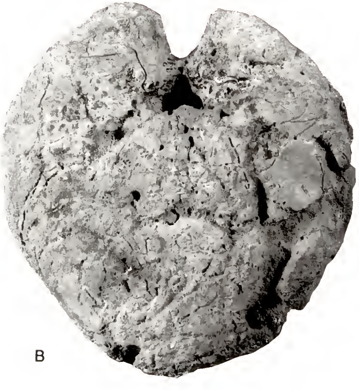

A
B
C
D
E
F

Figure 3-32. Pliocene irregular echinoids.

A) *Pericosmus* sp.; UF 66566; aboral view of phosphatized, partial internal mold of test; undetermined stratigraphic unit; 1x.

B) *Pericosmus* sp.; UF 66566; adoral view of phosphatized, partial internal mold of test; undetermined stratigraphic unit; 1x.

A



B

Figure 3-33. Pliocene irregular echinoids.

A) Agassizia porifera (Ravenel, 1848); UF 12894; aboral view of test; Caloosahatchee Formation; 1x.

B) Agassizia porifera (Ravenel, 1848); UF 12894; adoral view of test; Caloosahatchee Formation; 1x.

C) Plagiobrissus grandis (Gmelin, 1791); UF 22152; aboral view of partial test; Tamiami Formation; 0.75x.

D) Plagiobrissus grandis (Gmelin, 1791); UF 22152; adoral view of partial test; Tamiami Formation; 0.75x.

E) Plagiobrissus grandis (Gmelin, 1791); UF 22152; posterior view of test with the outline of periproct visible; Tamiami Formation; 0.75x.

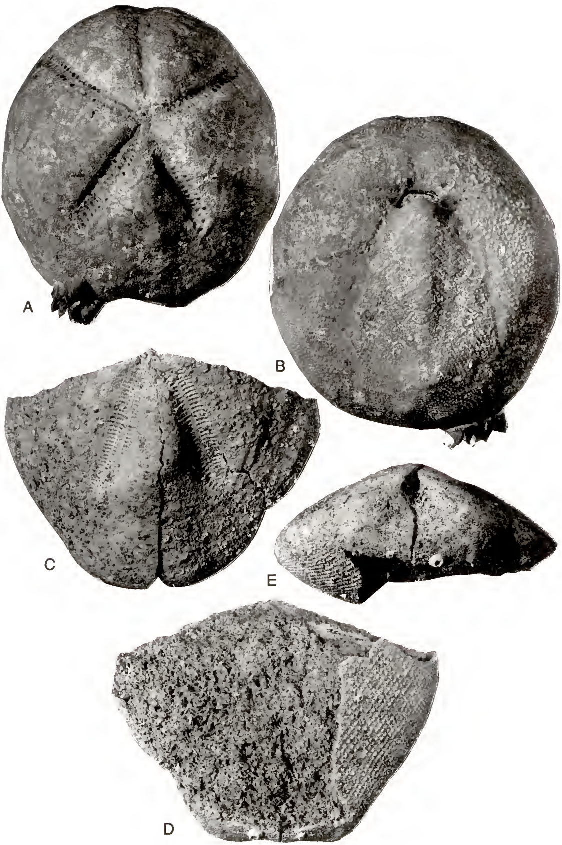

A
B
C
E
D

Figure 3-34. Pliocene irregular echinoids.

A) BRISSIDAE; UF 57743; aboral view of phosphatized, internal mold of test; undetermined stratigraphic unit; 1x.

B) BRISSIDAE; UF 57743; adoral view of phosphatized, internal mold of test; undetermined stratigraphic unit; 1x.

C) BRISSIDAE; UF 57743; lateral view of phosphatized, internal mold of test; undetermined stratigraphic unit; 1x.

D) Echinocardium orthonotum (Conrad, 1843); UF 60182; aboral view of test; Tamiami Formation; 1x.

E) Echinocardium orthonotum (Conrad, 1843); UF 60182; adoral view of test; Tamiami Formation; 1x.

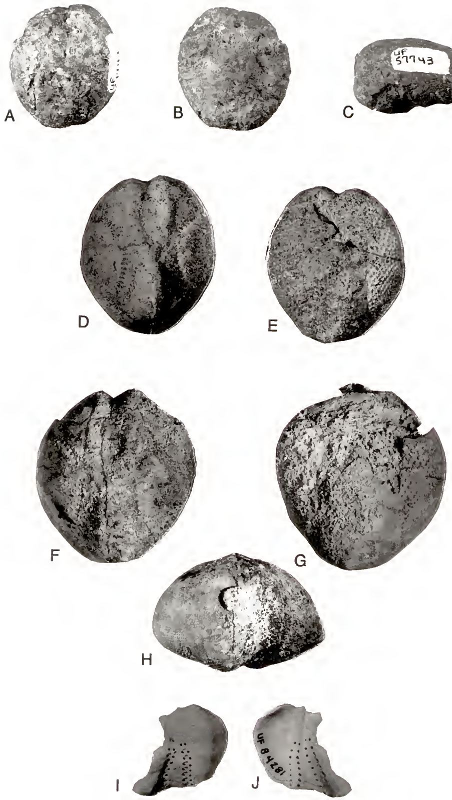
F) Echinocardium orthonotum (Conrad, 1843); UF 104522; aboral view of test; Intracoastal Formation; 1x.

G) Echinocardium orthonotum (Conrad, 1843); UF 104522; adoral view of test; Intracoastal Formation; 1x.

H) Echinocardium orthonotum (Conrad, 1843); UF 104522; posterior view of test with outline of periproct visible; Intracoastal Formation; 1x.

I) Echinocardium sp. cf. E. orthonotum (Conrad, 1843); UF 84281; aboral view of exterior of test fragment; Nashua Formation; 1x.

J) Echinocardium sp. cf. E. orthonotum (Conrad, 1843); UF 84281; aboral view of interior of test fragment; Nashua Formation; 1x.


A
B
UF
57743
C
D
E
F
G
H
I
UF 84281
J

the canal is deep and angular; ambulacra rapidly expanding from the extremities towards the dorsal suture; pores disunited; in the middle of the back a slight furrow crosses obliquely each of the anterior ambulacra at its termination; base plano-convex; anus large and remote from the margin; granulation on the back minute and very closely arranged, in the canal much smaller and more closely arranged towards the margins.

Echinocardium sp. cf. E. orthonotum (Conrad, 1843)
(Figure 3-34, I-J)

Material examined: UF 84281 (figured test fragment).

Formation: Nashua Formation.

Locality: Cracker Swamp Ranch 01 (PU004); Putnam County, FL; Hastings Quadrangle, SE1/4, SW1/4, Sec. 24, T9S, R27E.

Collectors: R. Portell, C. Oyen, et al.

Date: 6/26/96.

Description: One small test fragment, dominantly of an ambulacral region (either ambulacrum I or II). Test plates thin; tubercles small, densely spaced throughout. Distal end of ambulacrum with pore pairs curving slightly anterior. Pore pairs circular, large, widely separated and conjugate; two to three pores per ambulacral plate; petaloid structure moderately depressed. Ambitus broadly curving toward adoral surface (surface not present in sample, however).

Comments: Although very little of the original test was collected, the portion described matches well with the genus Echinocardium (see generic description provided earlier in Pliocene section). The fossil displays a similar

ambulacral structure as that of E. orthonotum, which is found in other Pliocene strata in Florida. Yet, just as in other cases of fragmented fossil echinoids, this identification must remain tentative until more complete specimens are available for comparison. Therefore, herein I refer to this specimen as Echinocardium sp. cf. E. orthonotum and include it as a new stratigraphic record for the Nashua Formation (both at the generic and specific levels) but do not include it as a new taxonomic record or as an additional species for the Pliocene diversity count.

Pleistocene Echinoids

Order Clypeasteroida A. Agassiz, 1872
Family Clypeasteridae L. Agassiz, 1835
Genus Clypeaster Lamarck, 1801

Description: See Oligocene echinoid section for generic description.

Florida species: Up to three species are present, including C. rosaceus (Linnaeus, 1758), C. rosaceus dalli (Twitchell, 1915), and an unidentified Clypeaster sp.

Comments: All fossils of Clypeaster are present in the Bermont Formation. The unidentified fossil (referred to as Clypeaster sp.) appears to be a new species, and therefore represents both a new stratigraphic and taxonomic record for the state.

Clypeaster rosaceus (Linnaeus, 1758)
(Figure 3-35, A-B)

Material examined: UF 42000 (figured test), UF 70612 (test), UF 63527 (test), UF 63940 (test), UF 63949 (test).

Description: Test large; horizontal outline subpentagonal; upper surface strongly inflated, with swollen petals; lower surface flat near the margin, with five conspicuous ambulacral grooves, deeply concave around the peristome; margin broadly rounded. Apical system central, with a large central madreporite; genital pores five, usually outside the apical system. Petals long, broad, swollen, completely closed at the apex, moderately open distally; poriferous zones proportionately narrow, strongly curved inward near the tips; pores circular, conjugate. Peristome central, deeply sunken, pentagonal. Periproct small, circular, submarginal. Tubercles sunken in small scrobicules, perforated.

Clypeaster rosaceus dalli (Twitchell, 1915)
(see Figure 3-21, A-B in Pliocene section)

Material examined: UF 63222 (test), UF 63300 (2 tests).

Description: See specific description in Pliocene section.

Clypeaster sp.
(Figure 3-35, C-D)

Material examined: UF 54188 (figured test).

Formation: Bermont Formation.

Locality: South Bay 04 (PB007), USA, Florida, Palm Beach County, Everglades 1 NW/ Everglades 1 NE Quadrangles, T46S, R37E.

Collector: McGinty Collection.

Date: 3/31/1968.

Description: Test small to medium size; horizontal outline subovate to subpentagonal with minimal marginal notches at interambulacra 1 and 4 and margin depressed slightly at interambulacrum 5. Anterior margin thick; posterior margin somewhat thinner. Aboral surface tumid, moderately raised in petaloidal region and apical system; margin broadly rounded; adoral surface moderately concave, increasing near peristome, with paired ambulacral furrows distinct and curving slightly toward each other at peristome. Apical system slightly broken, but located centrally, above peristome. Petals relatively short, extending about 50% of distance to margin; subequal length, with petaloid ambulacrum III only slightly longer; pore pairs close distinctly adapically, essentially disappearing, broaden two-thirds of way to end, then close at ends; pores conjugate; interporiferous zones broad. Peristome central, circular. Periproct inframarginal, small, round. Tubercles small.

Comments: This fossil is very well preserved and, after careful examination, compares most closely with C. subdepressus. However, it differs in overall size by being much smaller than adult C. subdepressus individuals, and secondly, the adoral surface is significantly more concave than the typical C. subdepressus. Unfortunately, only one specimen has been collected and until more collecting can be done in this unit to obtain additional specimens, I have chosen to leave this specimen identified only as Clypeaster sp. I believe the morphological differences warrant including this as a potentially new taxonomic record, as well as a new stratigraphic record (regardless of whether it is a new species or simply an unusual specimen of C. subdepressus).

Family Mellitidae Stefanini, 1911
Genus Encope L. Agassiz, 1840

Description: See Pliocene echinoid section for generic description.

Florida species: Two species are present, including E. aberrans Martens, 1867 and E. michelini L. Agassiz, 1841.

Comments: Both species are present in the Bermont Formation, and E. michelini also is present in the Anastasia Formation. The report herein of E. michelini in the Anastasia is a new stratigraphic record of this species. Both species of echinoids typically are fragmented, with specimens of E. michelini infrequently preserved as intact, whole fossils (excluding spines).

Encope aberrans Martens, 1867
(Figure 3-36, A-B)

Material examined: UF 42001 (figured test).

Description: Test spade shaped, longer than wide, highest behind the apical center, lower surface flat. Typically only two posterior ambulacral notches and a lunule, with the three anterior ambulacra only slightly indented. Apical system central, star shaped, with five genital pores. Petals broadly lanceolate, open; poriferous zones wide, pores conjugate; inner pores circular, larger than the outer pores, which tend to enlarge along the conjugations. Peristome small, central, circular, with five pairs of buccal tubes. Periproct oval, within the first postbasicoronal plates; covered with moveable plates.

Encope michelini L. Agassiz, 1841
(Figure 3-36, C-D and Figure 3-37, A-B)

Material examined: UF 62981 (figured test), UF 101080 (figured test), UF 64984 (test), UF 64985 (test), UF 67082 (3 tests), UF 67217 (2 tests).

Description: Horizontal outline elliptical, truncated behind; upper surface gently tumid, usually higher in front than behind; lower surface flat; margin thin. Posterior lunule long and rather wide. Five deep ambulacral notches, which tend to become oval and to close at the outer end. Apical system anterior; madreporite star shaped; five genital pores. Petals broadly lanceolate, extending more than halfway to the margin; poriferous zones wide, curved together at the outer ends but not closed. Peristome below the apical system, circular, with five pairs of buccal tubes. Food grooves diverging near the peristome and curving together around the notches; several branches near the margin. Periproct near the lunule.

Genus Mellita L. Agassiz, 1841

Description: See Pliocene echinoid section for generic description.

Florida species: M quinquiesperforata (Leske, 1778).

Comments: The species is present in two Pleistocene formations; the Anastasia Formation and the Satilla Formation. Specimens typically are poorly preserved and often fragmented, though specimens have been collected intact less frequently. This species represents a new stratigraphic record from the Satilla Formation of Florida.

Mellita quinquiesperforata (Leske, 1778)
(Figure 3-38, A-B)

Material examined: UF 14778 (figured test), UF 84156 – 84221 (one Recent test for each UF number).

Description: Horizontal outline subcircular, usually flattened behind and weakly notched in front; upper surface nearly flat, sloping evenly in all directions from the apical system to the very thin margin; lower surface flat. Test perforated by narrow radial slots near the outer ends of the paired ambulacra and by a longer slot in the median part of the posterior interambulacrum. Apical system having five small ocular pores; four genital pores at the paired interambulacral tips of the large star-shaped madreporite. Petals extending about halfway to the margin, anterior paired petals slightly shorter and more rounded than the others; poriferous zones about as wide as the interporiferous zones, open at the rounded tips. Peristome small, central. Periproct elongated, midway between the peristome and the posterior slot. Food grooves narrow, shallow, divaricating near the peristome, the branches nearly surrounding the ambulacra, starting from five nodes, each covering twin buccal tubes. Surface covered with short acicular spines, which are longest around the perforations and on the lower surface.

Order Spatangoida Claus, 1876
Family Schizasteridae Lambert, 1905
Genus Moira A. Agassiz, 1872

Description: Distinguished from Schizaster by deeply sunken nature of it petals.

Florida species: M. atropos (Lamarck, 1816).

Comments: The species is present in the Bermont Formation. This represents a new stratigraphic record of the species in Florida. In most instances fossils are highly fragmented, which probably has resulted in the lack of published information about this species' presence in the fossil record.

Moira atropos (Lamarck, 1816)
(Figure 3-39, A-H)

Material examined: UF 100180 (figured test), UF 12641 (figured Recent test).

Description: Horizontal outline suboval with an anterior notch, truncated behind; upper surface swollen behind, sloping steeply forward from the apical system; margin rounded; lower surface rounded. Apical system slightly posterior; two genital pores far apart, behind the anterior paired ocular pores but in line with the anterior ocular pore. Petals deeply sunken, depressions constricted at the top; posterior paired petals much shorter than the anterior pair. Peristome at the anterior quarter, reniform, strongly lipped. Periproct high on the posterior truncation, longer than wide. Peripetalous fasciole deeply indented in all five interambulacra, lying near the edges of the petals; lateral fascioles normal. Sutures bare. Long, curved spines.

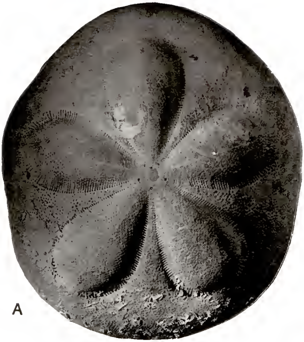
Figure 3-35. Pleistocene irregular echinoids.

A) Clypeaster rosaceus (Linnaeus, 1758); UF 42000; aboral view of test; Bermont Formation; 0.75x.

B) Clypeaster rosaceus (Linnaeus, 1758); UF 42000; adoral view of test; Bermont Formation; 0.75x.

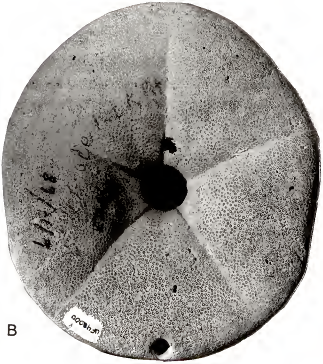
C) Clypeaster sp.; UF 54188; aboral view of test; Bermont Formation; 1x.

D) Clypeaster sp.; UF 54188; adoral view of test; Bermont Formation; 1x.



A

C



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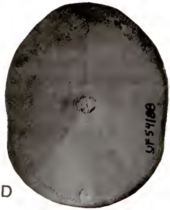


D

Figure 3-36. Pleistocene irregular echinoids.

A) Encope aberrans Martens, 1867; UF 42001; aboral view of test; Bermont Formation; 0.75x.

B) Encope aberrans Martens, 1867; UF 42001; adoral view of test; Bermont Formation; 0.75x.

C) Encope michelini L. Agassiz, 1841; UF 62981, aboral view of test; Anastasia Formation; 0.5x.

D) Encope michelini L. Agassiz, 1841; UF 62981, adoral view of test; Anastasia Formation; 0.5x.

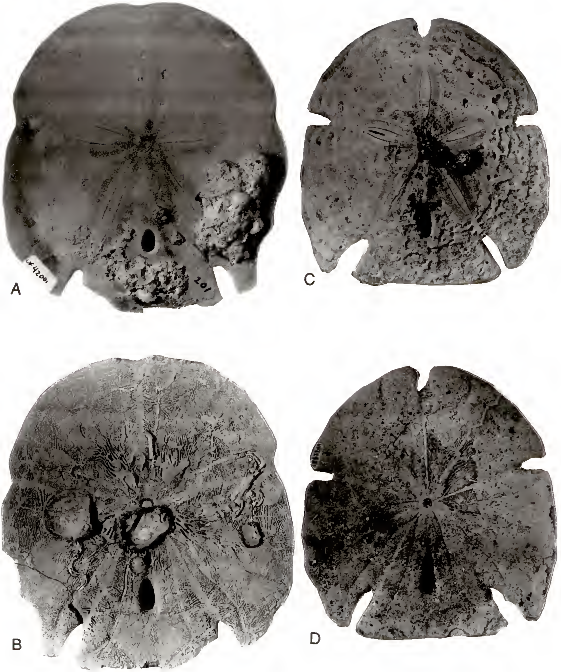

A
C
B
D

Figure 3-37. Pleistocene irregular echinoids.

A) Encope michelini L. Agassiz, 1841; UF 101080; aboral view of test; Bermont Formation; 0.75x

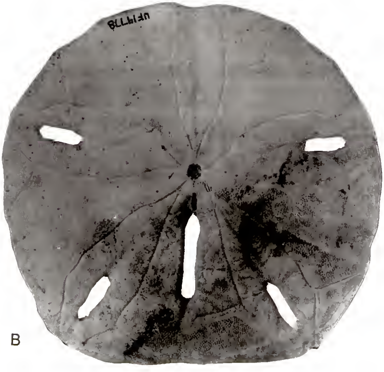
B) Encope michelini L. Agassiz, 1841; UF 101080; adoral view of test; Bermont Formation; 0.75x

A

B

Figure 3-38. Pleistocene irregular echinoids.
A) Mellita quinquiesperforata (Leske, 1778); UF 14778; aboral view of test; Satilla Formation; 1x.
B) Mellita quinquiesperforata (Leske, 1778); UF 14778; adoral view of test; Satilla Formation; 1x.

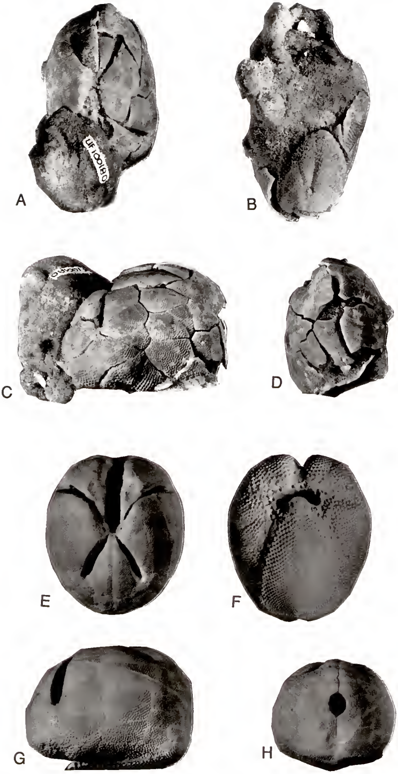
A



B

Figure 3-39. Pleistocene irregular echinoids and Recent specimens for comparison.

A) Moira atropos (Lamarck, 1816); UF 100180; aboral view of crushed test; Bermont Formation; 1x.
B) Moira atropos (Lamarck, 1816); UF 100180; adoral view of crushed test; Bermont Formation; 1x.
C) Moira atropos (Lamarck, 1816); UF 100180; lateral view of crushed test; Bermont Formation; 1x.
D) Moira atropos (Lamarck, 1816); UF 100180; posterior view of crushed test; Bermont Formation; 1x.
E) Moira atropos (Lamarck, 1816); UF 12641; aboral view of Recent test; 1x.
F) Moira atropos (Lamarck, 1816); UF 12641; adoral view of Recent test; 1x.
G) Moira atropos (Lamarck, 1816); UF 12641; lateral view of Recent test; 1x.
H) Moira atropos (Lamarck, 1816); UF 12641; posterior view of Recent test; 1x.


UF 100180
A
B
C
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Class Crinoidea Fossils

Lower Ocala Limestone Crinoids

Class Crinoidea Miller, 1821
Order Comatulida A.H. Clark, 1908
Family Himerometridae A.H. Clark, 1908
Genus Himerometra A.H. Clark, 1907

Description: Centrodorsal low hemispherical to discoidal with concave to deeply depressed dorsal area. Cirrus sockets without distinct ornament, closely placed in two or three irregular marginal circles. Cirrals with or without dorsal spines. Ventral side of centrodorsal with interradial ridges and Y-shaped coelomic furrows. Basal rosette, but no rod-shaped basal rays in Recent species. Radials with a low free surface or concealed. Articular face steep. Interarticular ligament fossae very large, separated by wide midradial furrow. Ventral muscular fossae form narrow bands along ventral edge. Radial cavity large. Arms divided at primibrachs 2 and secundibrachs 4, exceptional at secundibrachs 2, and often at tertibrachs 2 of inner branches and tertibrachs 4 of outer branches. Proximal brachials narrow, laterally free and well separated. Pinnules from secundibrachs 2 and tertibrachs 2 larger than succeeding pinnules. Proximal pinnules may be carinate. The Eocene species H. bassleri Gislén differs in absence of coelomic furrows and presence of rod-shaped basals. In the Oligocene H. grippae Anderson basals and coelomic furrows are unknown.

Florida species: H. bassleri Gislén, 1934.

Comments: The species is present in the Lower Ocala Limestone in peninsular Florida. Specimens consist of disarticulated ossicles including centrodorsals and brachials, as well as associated basal rays and radial plates.

Himerometra bassleri Gislén, 1934
(Figure 3-40, A-C)

Material examined: UF 39067 (figured centrodorsal), UF 39088 (figured centrodorsal), UF 39054-UF 39090 (50 centrodorsals, 53 radial plates, 20 basal rays).

Formation: Lower Ocala Limestone.

Locality: Inglis 01A (CI001); Citrus County, FL; Yankeetown Quadrangle, SE1/4, SE1/4, Sec. 9, T17S, R16E.

Collectors: FLMNH crew.

Date: 1974.

Description: Centrodorsal a flattened hemisphere; ventral outline irregular pentagonal shaped. Dorsal surface partly cirrus free with a deep depression, indistinctly lobate radially. Cirri in two to three alternating whorls, about nine in each radial area. Cirrus sockets with a very indistinct tubercle on each side of the nerve lumen; no striation discernible. Proximal cirrals short, then increasing in length. Outer cirrals shorter, again becoming compressed laterally and with faint dorsal carination ending distally in slight eminence; eminence gradually develops into blunt tubercle when length of cirral has decreased to approximate square shape. Opposing spine well developed. Terminal claw long and curved. Dorsal surface of radials smooth, rather narrow, broader at interradial corners. Dorsal ligament pit twice as broad as the nerve lumen. Interarticular fossae much larger than muscle impressions, which are only narrow ventral bands; a deep radial notch is present between muscle fossae. Radial cavity medium-sized to large, sloping toward the central

depression with numerous septal ridges. No central calcareous plug. Basal impressions of centrodorsal rather distinct; radial portions of ventral side almost smooth; entire ventral surface slightly concave. Proportion between centrodorsal diameter and centrodorsal cavity approximately 0.21-0.27. Radials with dorsal facet toward centrodorsal are smooth; smallest radials and radial rings have fewer septal ridges on slopes facing central depression. Fixed primibrachial smooth, well rounded laterally. Secundaxillary with fixed primibrachial forming a very distinct synarthrial eminence. Pimaxil pentagonal in shape. Arm bases rather slender, well separated laterally. All division series of brachials smooth with indistinct synarthrial eminences. Number of arms varies from 35 to 45. Arms are smooth, rather slender, and proportionally long-jointed. Proximal pinnules rather stout and smooth. Basal segments are short and angular, slightly carinate, the distal a little longer.

Upper Ocala Limestone Crinoids

Fam., gen. et sp. incertae
(Figure 3-40, D-G)

Material examined: UF 48126 (figured centrodorsal), UF 48125 (2 figured brachial plates).

Formation: Upper Ocala Limestone.

Locality: Wrights Creek (HO001); Holmes County, FL; Bonifay Quadrangle, SW1/4, SE1/4, Sec. 2, T5N, R15W.

Collector: S. Burttschell.

Date: 8/78.

Description: Centrodorsal pentagonal in horizontal outline; low dome or subhemispherical profile, broadly curving. Cirrus sockets in 3 horizontal rows, closely spaced with smallest sockets near dorsal apex. Ventral surface with moderate-sized radial cavity; opening approximately 0.4 of ventral surface diameter. Basal and radial plates, cirri, and arms not present on specimen.

Comments: The fossils collected from Holmes County are identified as comatulid crinoids, but more precise taxonomic identification has not been attempted at this time. Very limited research is available regarding North American comatulids, and this also is true worldwide with respect to fossil comatulid crinoids. Therefore, documentation and reference materials (both as actual specimens and literature) are exceptionally difficult to obtain for comparison purposes. Review of the Treatise of Invertebrate Paleontology and the most thorough monograph series on modern crinoids written to date by A.H. Clark (i.e., Clark, 1915, 1921, 1931, 1941, 1947, 1950; Clark and Clark, 1967) resulted in no clear matches for these fossils. Therefore, I interpret the specimens to represent a new fossil species awaiting formal description. Herein the fossils are counted as a unique species of crinoid for the echinoderm diversity total. I consider them to be a new taxonomic record, but do not include this taxon as a new stratigraphic record since they have been reported earlier (Oyen, 1995).

Class Asteroidea Fossils

Eocene Asteroids

Class Asteroidea de Blainville, 1830
Family Oreasteridae Fisher, 1911
Genus Goniodiscaster H.L. Clark, 1909

Description: Massive, flat body form with disc relatively large; pentagonal; arms typically 5, short; very broad at base, abactinal plates stellate, typically six-pointed, adradial facets of near radial ossicles highly elongate; some near radial ossicles transversely elongate. Actinals elliptical.

Comments: One or more species may be present in the Ocala Limestone. However, until more complete specimens are discovered no definitive taxonomic placement is possible.

cf. Goniodiscaster sp.
(Figures 3-40, H-J and 3-41, A-B)

Material examined: UF 28135-UF 28137 (figured external molds of juveniles), UF 50000 (figured partial test), UF 38251 (figured marginal ossicle), UF 17244 (figured silicone peel of external mold and external mold of test).

Formation: Ocala Limestone.

Locality: Dickerson Limerock Mines (Haile Complex) (AL004); Alachua County, FL, Newberry Quadrangle, T9S, R17E, Inglis 01A (CI001), Citrus County, Yankeetown Quadrangle, SE1/4, SE1/4, Sec. 9, T17S, R16E, Dolime Quarry 01 (CI009), Citrus County, Yankeetown Quadrangle, SE1/4, Sec. 11, T17S, R16E.

Collector: R. Portell and Jon Bryan (UF 28135-UF 28137), C. Oyen (UF 50000), FLMNH Crew (UF 38251), R. Portell and Jon Bryan (UF 17244).

Date. 03/18/88, 03/4/89, 1974, 3/18/88 (respectively).

Description: UF 50000 - body form flat, disc large, length of major radius 85 mm and length of minor radius 50 mm, arms 5, arms very broad at base; Superomarinals large and inflated, paired with long axes oriented perpendicular to arm margins; no visible pores; madreporite not visible; no spines present. UF 17244 - abactinal ossicles stellate (six pointed).

Comments: Specimens UF 28135-UF 28137 are external molds of juvenile asteroids which are more difficult to identify. However, their larger superomarginal ossicles help with taxonomic placement. A modern oreasterid species is shown for comparison purposes in Figure 3-42. Isolated ossicles are common in the Ocala Limestone and because of their large size, easy to find. Articulated specimens (whether molds or original material) are very rare. Specimens were found in the Upper and Lower Ocala Limestone.

Oligocene Asteroids

cf. Goniodiscaster sp.

Material examined: UF 27464 (42 isolated ossicles).

Formation: Suwannee Limestone.

Locality: Terramar 01 (PO017), Polk County, Socrum Quadrangle, S1/4, Sec. 10, T26S, R22E.

Collectors: R. Portell et al.

Date: 09/06/89

Description: See Eocene section for description of cf. Goniodiscaster sp.

Comments: Oligocene sea star ossicles are not nearly as common as those from the Ocala Limestone and they do not reach the large proportions as specimens of Eocene age.

Miocene Asteroids

Order Paxillosida Perrier, 1884
Family Astropectinidae Gray, 1840
Gen. et sp. incertae

Material examined: UF 25333 (3 isolated superomarginal ossicles), UF 32651 (superomarginal ossicle), UF 25132 (superomarginal ossicle).

Formation: Parachucla Formation.

Locality: White Springs (HA001); Hamilton/Columbia counties. FL; W1/4, NW1/4, SW1/4, Sec. 7, T2S, R16E.

Collectors: R. Portell and G. Morgan.

Date: 12/13/89.

Description: Marginal ossicles small; longer than wide (average length 4 mm, average width 2 mm).

Comments: Until better preserved material is found (possibly a partially articulated specimen) precise taxonomic assignment is problematic. A modern astropectinid species is shown for comparison purposes in Figure 3-42.

Pliocene Asteroids

Order Forcipulatida Perrier, 1884
Family Heliasteridae Viguier, 1878
Genus Heliaster Gray, 1840

Description: Disc large, not set off externally from the fused bases of the rays, little elevated, with reticulated abactinal skeleton, and more or less numerous spines, pedicellariae, and papulae. Rays numerous, more than 20 in normal adults, more or less united at base, so that only a relatively small part (15-70%) is free. Adambulacral armature variable, usually single, sometimes double, especially near tip of ray; spines of alternate plates often of two sharply contrasted sizes, especially near base of ray. Pedicels arranged in two somewhat zigzag rows, so that near the middle of the ray they are distinctly quadriserial. Forcipate and forticate pedicellariae both present, the latter often of two distinct sizes. Interbrachial septa double and well developed, expanding at inner (proximal) end and uniting laterally, to form a discobrachial wall, so the cavity of the disc is almost completely separated from the ray cavities.

Florida species: Heliaster microbrachius Xantus, 1860.

Comments: This species is present in the Tamiami Formation (Pliocene). Jones and Portell (1988) published the first fossil record of this species based upon these well-preserved fossils from southwestern Florida. The fossils are found within a matrix of quartz sand cemented with calcite and often are densely distributed as a result of imbrication of the sea stars. Jones and Portell (1988) reported finding the remains of over 360 individuals at the single locality in Charlotte County, with many individuals complete or nearly complete.

Heliaster microbrachius Xantus, 1860
(Figure 43, A)

Description: Rays total 27-44; rays more or less flattened abactinally, tapering rather sharply to a blunt point. Disc very large, somewhat elevated in well-preserved specimens, but not abruptly so. Abactinal skeleton stout, closely reticulated, with small meshes. Abactinal spines very numerous, 30-50 or more per square cm, small, usually low, more or less cylindrical and without definite arrangement. In some large specimens, spines show slight tendency to be capitate, and in many cases are very compressed. In some individuals spines on rays form five fairly distinct series, traceable inward for a variable distance onto the disc. At edge of disc the marginal series of adjoining rays sometimes very clearly separated by a bare space. Sides of ray with two series of compressed spines. Actinal surface very much as in H. helianthus, but pedicellariae are less frequent and reduction of the adambulacral armature reaches its extreme; in large specimens only every other adambulacral plate bears a spine until the distal half or third of furrow is reached, and even at extreme tip of the ray it is rare to find a plate with two spines. Pedicels numerous, distinctly quadriserial at middle of ray. Madreporite rather small, often concave, and usually fragmented.

Order Paxillosida Perrier, 1884
Family Astropectinidae Gray, 1840
Gen. et sp. incertae

Material examined: UF 48093 (2 superomarginal ossicles).

Formation: Tamiami Formation.

Locality: Lomax-King Pit A (CH028), Charlotte County, FL; Punta Gorda Quadrangle, SW1/4, SE1/4, Sec.28, T41S, R23E.

Collector: R. Portell.

Date: 12/23/88

Description: Marginal ossicles small; longer than wide. Intermarginal facet well-defined.

Comments: Until better preserved material is found (possibly a partially articulated specimen) precise taxonomic assignment is problematic.

Order Paxillosida Perrier, 1884
Family Luidiidae Sladen, 1899
Genus Luidia Forbes, 1839

Description: Arms long, flat, strap-like, numbering from a minimum of five total to several more (undefined). Small central disc; absence of superomarginal plates; paxillar abactinal surface and elongate inferomarginal plates extending from the ambitus to the adambulacral plates. Inferomarginal ossicles with a conspicuous fringe of inferomarginal spines.

Florida species: Luidia sp.

Comments: This genus is represented by an incomplete specimen of a species waiting formal description. The fossil is from the Tamiami Formation and was collected in association with the Heliaster microbrachius described herein.

Luidia sp.
(Figure 3-43, B)

Material examined: UF 60184 (one incomplete test).

Formation: Tamiami Formation.

Locality: El Jobean 01 (CH002); Charlotte County, FL; El Jobean Quadrangle, SW1/4, NE1/4, Sec. 21, T40S, R21E.

Collector: D. Swanson.

Date: Unknown.

Description: Five-armed asteroid; aboral surface with two partial arms; portion of central disk visible but distorted. Major radius at least 46.5 mm, minor radius 14.7 mm. Arms elliptical, strap-like, disk rather flat, small; arm taper gradual; madreporite nor spines visible.

Comment: This is the first report of the genus from the Cenozoic of the southeastern United States. A nearly complete test of this taxon is currently in the hands of a private collector. Hopefully it will be donated to a museum for formal description.

Class Ophiuroidea Fossils

Eocene Ophiuroids

Class Ophiuroidea Gray, 1840
Order Ophiurida Müller and Troschel, 1840

Florida species: All identifications limited to taxonomic order at this time, with only one tentative proposal at the familial level.

Comments: Most fossils collected thus far consist of disarticulated vertebral ossicles, thereby limiting the potential for lower level identifications. Ophiurioid taxonomy is based mainly on the features of the disk and the gross anatomy of complete specimens. Currently, no reference exists for identification

of disarticulated vertebral ossicles. Ophiuroids are present in the Avon Park Formation (Eocene), Marks Head Formation (Miocene), and Tamiami Formation (Pliocene) in Florida.

cf. Amphiuridae
Gen. et sp. indet.
(Figure 3-40, H)

Material examined: UF28129-28130 (figured external molds of juveniles on Thalassodendron seagrass blades.

Formation: Avon Park Formation.

Locality: Dolime Quarry 01A (CI013); Citrus County, FL; Yankeetown Quadrangle, SE1/4, Sec. 11, T17S, R16E.

Collectors R. Portell and J. Bryan.

Date: 03/18/88.

Description: Individuals with five arms that are long and thin with short erect spines.

Comments: UF 28129-28130 are external molds of juvenile specimens which are more difficult to identify. Specimens have been found only associated with sea grass fossils in the Avon Park Formation.

Miocene Ophiuroids

Gen. et sp. indet.
(Figure 3-43, C)

Material examined: UF 45853 (figured vertebral ossicle).

Formation: Marks Head Formation.

Locality: Brooks Sink (BF001); Bradford County, FL; Brooker Quadrangle, SW1/4, SW1/4, Sec. 12, T7S, R20E.

Collector: R. Portell.

Date: 01/14/88.

Description: Four disarticulated vertebral ossicles; small (one to two mm diameter); micromorphological structures such as vertical dumbbell, dorsal muscle attachment, ventral muscle attachment, ventral nose, and podial basin are preserved and visible.

Comments: The fossil ophiuroid ossicles from Brooks Sink are well-preserved, but due to the limited number of skeletal components, identification to lower taxonomic levels is not possible. The fossils are important, however, because they prove that ophiuroids have a fossil record in Florida, and with detailed examination of the fine-fraction of disaggregated limestones it is possible to recover such taxa. For the purpose of biostratigraphic analysis in this dissertation, these fossils represent a new stratigraphic record for the Marks Head Formation, but cannot be considered as a new taxonomic record without additional, more complete material for identification.

Pliocene Ophiuroids

Gen. et sp. incertae sedis
(Figure 3-43, D)

Material examined: UF 7380 (complete but recrystallized test).

Formation: Tamiami Formation.

Locality: El Jobean 01 (CH002); Charlotte County, FL; El Jobean Quadrangle, SW1/4, NE1/4, Sec. 21, T40S, R21E.

Collector: R. Portell.

Date: 4/86.

Description: Arms five, generally subcircular in outline, narrowing toward the distal termination; short conical spines on arms; disc covered by fine imbricating scales and minute spines; specimen recrystallized preventing more detailed description.

Comments: UF 7380 is preserved on the sun star Heliaster microbrachius. It is very small (up to three cm or slightly less in diameter with arms extended). The detailed morphology of this ophiuroid is obscured by recrystallization of calcite and by surficial cemented matrix. The combination of small size and attached matrix prevents more precise taxonomic identification of the fossils. Herein, I do not consider the identification to reflect a new stratigraphic record or a new taxonomic record based solely on these fossils, but rather only note these as an occurrence of the class Ophiuroidea from the Tamiami Formation.

Figure 3-40. Eocene crinoids, asteroids, and ophiuroids.

A) *Himerometra bassleri* Gislén; UF 39067; dorsal view of centrodorsal element; Ocala Limestone; 3x.

B) *Himerometra bassleri* Gislén; UF 39067; ventral view of centrodorsal element with attached radial plates; Ocala Limestone; 3x.

C) *Himerometra bassleri* Gislén; UF 39088;ventral view of centrodorsal element with radial plates removed (allowing distinctive rod-shaped basal rays to be observed); Ocala Limestone; 3x.

D) Unidentified comatulid crinoid; UF 48126; dorsal view of centrodorsal element; Ocala Limestone; 7x.

E) Unidentified comatulid crinoid; UF 48126; ventral view of centrodorsal element; Ocala Limestone; 7x.

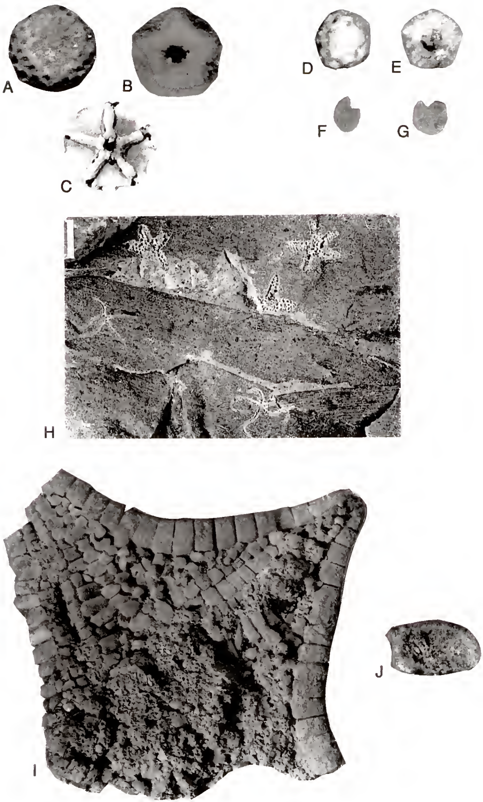
F) Unidentified comatulid crinoid; UF 48125; brachial plate; Ocala Limestone; 7x.

G) Unidentified comatulid crinoid; UF 48125; brachial plate; Ocala Limestone; 7x.

H) cf. *Goniodiscaster* sp. and cf. *Amphiuridae* gen. et sp. indet.; UF 28135-28137 (asteroids) and UF28129-28130 (ophiuroids); external molds of unidentified juveniles among *Thalassodendron auricula-leporis* seagrass blades; Avon Park Formation; 2x.

I) cf. *Goniodiscaster* sp.; UF 50000; view of specimen showing marginals and abactinal ossicles; Ocala Limestone; 1x.

J) cf. *Goniodiscaster* sp.; UF 38251; lateral view of marginal ossicle; Ocala Limestone; 2x.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I
J

Figure 3-41. Eocene asteroid and silicone rubber peel.

A) cf. Goniodiscaster sp.; UF 17244; RTV silicone rubber peel of incomplete test; Ocala Limestone; 1x.

B) cf. Goniodiscaster sp.; UF 17244; external mold of incomplete test; Ocala Limestone; 1x.

A

B

Figure 3-42. Recent asteroids illustrating articulated ossicle arrangements that may be similar to taxa in Florida's fossil record.

A) Oreaster reticulatus (Linnaeus, 1758); UF105550; adoral view of Recent test, collected offshore near Tampa, FL, showing large marginal ossicles; 1x.

B) Astropecten sp.; UF30969; aboral view of Recent test, collected from the Gulf of Mexico, showing marginal ossicles; 1x.

C) Astropecten sp.; UF30969; adoral view of Recent test, collected from the Gulf of Mexico, showing marginal ossicles; 1x.

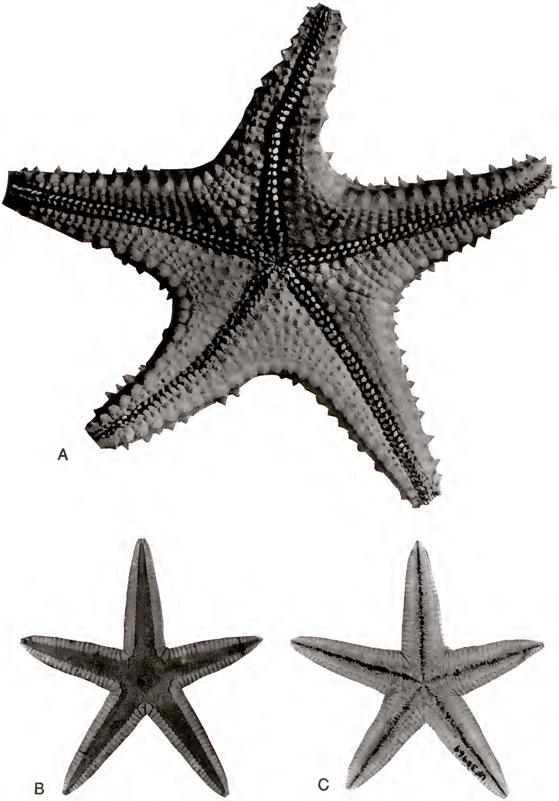

A
B
C

Figure 3-43. Pliocene asteroids along with Miocene and Pliocene ophiuroids.

A) Heliaster microbrachius Xantus; UF 7423; top view of block with over 12 individuals preserved in sandstone; Pliocene, Tamiami Formation, 0.3x.

B) Luidia sp.; UF 60184; top view of two nearly complete rays, adhered to Heliaster microbrachius block; Pliocene, Tamiami Formation; 1x.

C) Ophiuroid; UF lot 45853; vertebral ossicle; Miocene, Marks Head Formation; 7x.

D) Unidentified ophiuroid; UF 7380; specimen nestled among rays of Heliaster microbrachius; Pliocene, Tamiami Formation; 1.5x.

A

C

B

D

CHAPTER 4
ECHINODERM DIVERSITY PATTERNS AND BIASES

Taxonomic and Biostratigraphic Discussion

Several points should be noted about the data presented in this paper with respect to taxonomic and stratigraphic records. Complete tests, test fragments, spines, and molds were included in the echinoid database, as well as articulated and disarticulated ossicles, and some molds of crinoids, asteroids, and ophiuroids are part of my records. New stratigraphic records include any echinoderms reported herein that have not been previously published elsewhere when referring to that particular stratigraphic unit. This may have some bias associated with it due to stratigraphic nomenclature changes, and it is discussed in more detail in a later section on biases in the Florida echinoderm record. The taxonomic records include old and new (but not yet formally described) taxa. I have not counted subspecies as unique taxa because, in my opinion, most of them need to be re-examined for possible synonymy. Additional specific notes regarding newly reported taxa are included in the systematic paleontology chapter earlier in this dissertation. Finally, most of the uncertain records (both taxonomic and stratigraphic) were omitted to provide a conservative and reliable database for presentation in this paper.

Eocene Echinoids

Fossil echinoids from the Eocene in Florida are reasonably well-known and diverse. A variety of fossils from the carbonates of the Middle and Upper Eocene have been collected by paleontologists for more than 150 years. Consequently, most of the Eocene taxa and biostratigraphic records are not new. When compared with other epochs, the Eocene shows little change (proportionally) in terms of new stratigraphic occurrences or potential new taxa. I interpret this to be a result of the many years of intensive collecting. A second factor, which may contribute to the relatively small number of new Eocene echinoid records, is the good preservation of the calcitic tests in the carbonates. These tend to be preserved as complete or nearly complete specimens, unlike many echinoids of the siliciclastic-rich Neogene units. The preservation bias will be discussed in more detail later.

The Eocene exhibits the highest number of taxa of any epoch from the Middle Eocene through the Pleistocene. The proportion of echinoid taxa during this epoch is three (= 7.9%) regular echinoids to 35 (= 92.1%) irregular echinoids, bringing the total number to 38 (Figure 4-1).

The regular echinoids are represented by the genera Phyllacanthus and Dixieus, as well as fragments and spines of another taxon that is a diadematoid. Of the regular echinoids, Phyllacanthus is most abundant, yet specimens are relatively rare as complete or nearly complete tests. All the regular echinoid taxa are found in the Upper Ocala Limestone while only Phyllacanthus is also present in the Lower Ocala Limestone. In many cases, the regular echinoid fossils are

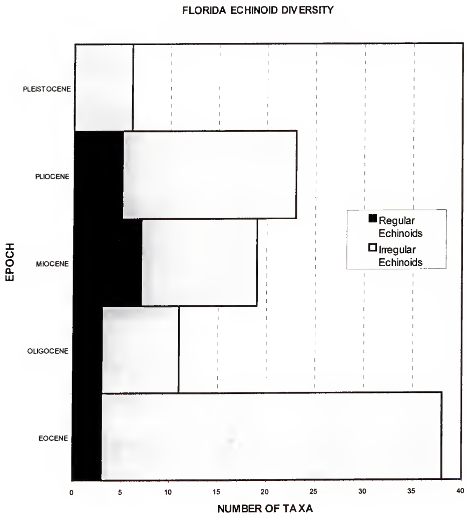


Figure 4-1. Irregular and regular echinoid diversity reflecting updated values as a result of this study. Data are provided at epoch level resolution, and the light stipple pattern corresponds to irregular echinoid species while the black pattern represents regular echinoid species.

broken or disarticulated, and may be represented by only plate fragments, radioles, or Aristotle's lantern components.

The Eocene irregular echinoids are the most diverse segment of the fossil echinoderm record of Florida. Twenty-two genera (Table 4-1) are found in rocks

from the Avon Park, Lower and Upper Ocala Limestone (see Figure 2-1, chapter 2). Several genera, including Oligopygus, Rhyncholampas, Schizaster, and Eupatagus, have three to four species each and thereby are more species-rich than most of the other Eocene genera. The irregular echinoids generally have better preservation than the regular echinoids, though this is typical of preservation comparisons between the two groups throughout their entire fossil record and is not unique to the Eocene or to Florida echinoids (Kier, 1977; Donovan, 1991; Greenstein, 1993). Although there are numerous taxa, less than half of the species are common, and are easily found while conducting fieldwork. The four genera listed above, along with Weisbordella, Durhamella, Neolaganum, and Periarchus (see Figures 3-1 through 3-4, chapter 3), are common constituents of the Florida Eocene.

One group of echinoids has been used as an important stratigraphic tool for the Late Eocene. Zachos and Shaak (1978) developed a biostratigraphic scheme based on distribution of the three species of Oligopygus echinoids found in Florida, O. phelani Kier, O. haldemani (Conrad), and O. wetherbyi de Loriol (Figure 3-1). These echinoids work as good biostratigraphic markers because they are well-preserved, abundant, and easy to identify in the field. The species O. phelani is restricted to the Lower Ocala Limestone, with both O. haldemani and O. wetherbyi confined to the Upper Ocala Limestone. Most facies of the Ocala Limestone contain these echinoids and they are useful index fossils for field studies of the Middle to Late Eocene limestones of Florida.

Table 4-1. Eocene echinoderms and the formations from which the fossils were collected.

GENUS	# OF TAXA	FORMATION(S)
ECHINOIDS		
Phyllacanthus	1	Upper Ocala Ls
		Lower Ocala Ls
Dixieus	1	Upper Ocala Ls
Diadematoida	1	Upper Ocala Ls
Oligopygus	3	Upper Ocala Ls
		Lower Ocala Ls
Amblypygus	1	Upper Ocala Ls
Fibularia	1	Upper Ocala Ls
		Lower Ocala Ls
Periarchus	1	Lower Ocala Ls
Protoscutella	1	uncertain
Weisbordella	2	Upper Ocala Ls
Durhamella	2	Upper Ocala Ls
Neolaganum	2	Upper Ocala Ls
		Avon Park Fm
Wythella	1	Upper Ocala Ls
Eurhodia	1	Upper Ocala Ls
Echinolampas	1	Upper Ocala Ls
Rhyncholampas	4	Upper Ocala Ls
		Lower Ocala Ls
Schizaster	3	Upper Ocala Ls
Ditremaster	1	Upper Ocala Ls
Agassizia	2	Upper Ocala Ls
		Lower Ocala Ls
Macropneustes	1	Upper Ocala Ls
Brissopsis	2	Upper Ocala Ls
Plagiobrissus	2	Upper Ocala Ls
		Lower Ocala Ls
Eupatagus	3	Upper Ocala Ls
		Lower Ocala Ls
Mortonella	1	Upper Ocala Ls
CRINOIDS		
Himerometra	1	Lower Ocala Ls
gen. indet.	1	Upper Ocala Ls
ASTEROIDS		
Oreasteridae or	?	Upper Ocala Ls
Goniasteridae		Lower Ocala Ls
		Avon Park Fm
OPHIUROIDS		
gen. indet.	?	Avon Park Fm

The stratigraphic distribution of echinoids in the Middle Eocene Avon Park Formation is limited to one species of irregular echinoid, Neolaganum dalli, Twitchell (Figure 3-3), and no new stratigraphic records or new taxonomic records are reported for this formation. The Lower Ocala Limestone contains 10 species (one regular and nine irregular echinoid species), with no new taxonomic or stratigraphic records from the unit. All of the changes in the Eocene data are found in the Upper Ocala Limestone. Within this unit, 29 species are present (three regular and 26 irregular echinoid species), and I report five new stratigraphic records and three new taxonomic records for this formation.

An interesting aspect of the echinoid stratigraphic distributions in Florida is the relatively limited range of species. This likely is an artifact of the stratigraphic nomenclature itself within the state, since many of the formations were named (at least in part) on the basis of fossils. This will be addressed in more detail in following sections of this chapter, but at this point I will note which taxa are present in more than one stratigraphic unit (in the Eocene I consider the Upper Ocala Limestone and the Lower Ocala Limestone to be unique). This characteristic is relatively unusual for echinoids in Florida, with only three taxa that have this stratigraphic distinction in the Eocene. These are: Phyllacanthus mortoni (Conrad) (Lower and Upper Ocala Limestone), Fibularia vaughani (Twitchell) (Lower and Upper Ocala Limestone), and Plagiobrissus curvus (Cooke) (Lower and Upper Ocala Limestone).

Oligocene Echinoids

The Oligocene is at the lower end of the spectrum of echinoid species diversity in the Florida fossil record. A dramatic decrease in the number of taxa from the Eocene to the Oligocene is obvious in the pattern of species diversity at that time (Figure 4-2). The Oligocene carbonates contain 11 total taxa, with the proportion of regular to irregular echinoids at three (= 27.3%) to eight (= 72.7%) respectively (Figure 4-1). Therefore, this total diversity represents a considerable drop from 38 taxa in the Eocene. The origin of this dramatic decrease in diversity is not well defined yet, but a similar pattern has been noted globally for both terrestrial and marine organisms (see Prothero and Berggren, 1992). One attempt to identify the cause of the echinoid diversity decrease from the Eocene to the Oligocene was by McKinney and Oyen (1989). They proposed that a temperature decrease more strongly correlated with the diversity drop than a lowering of sea level, which also matched the cause proposed for the Gulf Coast mollusk diversity drop (Dockery, 1986). Later, McKinney et al. (1992) expanded the focus and examined the global echinoid pattern across the Eocene-Oligocene boundary. They found a similar pattern in the global echinoid data as existed in the Gulf Coast region, and again proposed temperature decrease to be the cause of the diversity drop. This pattern is discussed in more detail in subsequent paragraphs of the chapter.

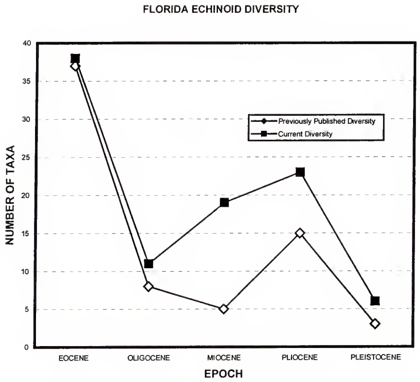


Figure 4-2. Echinoid diversity curves for Florida. Open diamonds represent previously published taxonomic records while the black squares show the updated diversity values. Note distinct change in diversity trend from the Oligocene to the Miocene as a result of the data presented herein.

The regular echinoid species of the Oligocene are members of two genera, Gagaria and Phymotaxis. Though none of the species are common, Gagaria mossomi (Cooke) tends to be more prevalent than the other regular echinoids (Figure 3-9). All of the Oligocene regular echinoids known from Florida are found in the Suwannee Limestone. The typical pattern of fragmented and poorly preserved regular echinoids holds true for Oligocene taxa.

The irregular echinoids are represented by species from five genera (Table 4-2). The most diverse genus is Clypeaster, which has four species, and fossils from this genus are found in all three of the echinoid-bearing Oligocene formations in Florida. The most common species is C. rogersi (Morton), which occurs in both the Marianna Limestone of northern Florida and the Suwannee Limestone (Figure 3-13). The most pervasive and abundant echinoid in the Oligocene is Rhyncholampas gouldii (Bouvé), which is present in the Suwannee Limestone throughout most of the unit's areal extent (Figure 3-13). This species normally is well-preserved, easily identified in the field, and occurs in lithofacies varying from wackestones to grainstones (though more common in the sandier, higher energy end of the facies spectrum).

Within the Oligocene, the 11 taxa I report herein are distributed among three formations (Figure 2-1). The Suwannee Limestone is the most diverse stratigraphic unit, with all 11 taxa found in the formation. I present five new stratigraphic records for the formation and two new taxonomic records. The Marianna Limestone has two species of echinoids, with one new stratigraphic record and no new taxonomic records. The Bridgeboro Limestone also has a total of two taxa, neither represents a new stratigraphic record nor a new taxonomic record for the state.

Finally, four taxa are found in more than one formation of Oligocene age, which is proportionally high for Florida echinoids. These include: Clypeaster cotteaui Egozcue (Suwannee Limestone and Bridgeboro Formation), C. rogersi (Morton) (Suwannee Limestone and Marianna Limestone), Agassizia mossomi

Table 4-2. Oligocene echinoderms and the formations from which the fossils were collected.

GENUS	# OF TAXA	FORMATION(S)
ECHINOIDS		
Gagaria	1	Suwannee Ls
Phymotaxis	2	Suwannee Ls
Clypeaster	4	Bridgeboro Ls
		Marianna Ls
		Suwannee Ls
Rhyncholampas	1	Suwannee Ls
Agassizia	1	Bridgeboro Ls
		Suwannee Ls
Schizaster	1	Marianna Ls
		Suwannee Ls
Brissopsis	1	Suwannee Ls
CRINOIDS	none	
ASTEROIDS		
Oreasteridae	?	Bridgeboro Ls
		Suwannee Ls
OPHIUROIDS	none	

Cooke (Suwannee Limestone and Bridgeboro Formation), and Schizaster americanus Clark (Suwannee Limestone and Marianna Limestone).

Miocene Echinoids

The Miocene shows the greatest change from previously published information on echinoid diversity (Figure 4-2). The increase in new taxa (11) and new stratigraphic records (16) is dramatic and represents a modification in the

overall pattern seen throughout the Cenozoic strata of Florida. Prior to my revisions in taxonomic and stratigraphic records, the diversity trend for echinoids in the state (as well as throughout the Gulf Coastal Plain) showed a marked drop from the Oligocene into the Miocene. An example of this pattern can be seen at a slightly broader scale for the southeastern U.S. and Caribbean echinoids in work done by McKinney and Oyen (1989) and McKinney et al. (1992). However, this drop in diversity was anomalous when compared with the global pattern, which shows an increase in diversity from the Oligocene to the Miocene (Kier, 1977; McKinney et al., 1992). I believe this large increase in the known distribution of Florida echinoids is strongly a function of collector bias, because many of the additions I have made are based on incomplete specimens or poorly preserved (moldic) specimens, which many collectors tend to disregard (biases discussed below). The diversity data, therefore, fit the global echinoid pattern much more closely following my revision. The siliciclastic and carbonate units of the Miocene contain a total of 19 taxa, with 7 of these regular echinoids (= 36.8%) and 12 irregular echinoids (63.2%).

The echinoids of the Miocene represent the highest proportion of regular to irregular echinoid taxa from the Eocene through the Pleistocene. Four genera of regular echinoids are present in the Miocene, including Gagaria, Psammechinus, Arbia, and Prionocidaris. Most of the regular echinoids are uncommon, but with closer examination of sediment samples such fragments are being recovered with increasing frequency. One exception to this pattern is Prionocidaris, whose test plates and radioles are common at most Chipola

Formation localities. Two examples of this incomplete (moldic) preservation can be seen in the photos of Figure 3-14 (in chapter 3).

A total of at least eight genera of irregular echinoids are present in Florida's Miocene units (Table 4-3). Most of these echinoids are not common. The best examples of locally concentrated specimens include internal and external molds of Lovenia clarki (Lambert) (Chattahoochee Formation) in Jackson County, and internal molds and tests of Abertella aberti (Conrad) (Coosawhatchie, Arcadia, and Peace River formations) from several locations in the state (Figures 3-16 and 3-18). Preservation of the Miocene echinoids rarely is complete and therefore identification to lower taxonomic levels is more difficult. Thus, my close examination of incomplete specimens partially accounts for the diversity increase in the Miocene. Since my taxonomic record data have been culled to include only specimens that are likely to be described as new species, and several fossils were omitted pending more detailed preparation and examination, I believe the number of taxonomic records will increase even more as my work continues.

The echinoids from this epoch are found in nine of the ten echinoderm-bearing formations (Figure 2-1). The Chipola Formation has the greatest number of taxa (eight total), including several which may be undescribed species. Recently, Rhyncholampas chipolanus Oyen and Portell was described from the Chipola Formation based on a single, well-preserved specimen (Figure 3-16). Since that description, additional test fragments from other individuals of this

Table 4-3. Miocene echinoderms and the formations from which the fossils were collected.

GENUS	# OF TAXA	FORMATION(S)
ECHINOIDS		
Gagaria	2	Parachucla Fm
Arbia	1	Chattahoochee Fm
Psammechinus	1	Chipola Fm
Prionocidaris	1	Chipola Fm
		Torreya Fm
gen. indet.	3	Arcadia Fm
		Chattahoochee Fm
		Shoal River Fm
Mellitidae	1	Statenville Fm
Abertella	2	Arcadia Fm
		Chipola Fm
		Coosawhatchie Fm
		Peace River Fm
		Torreya Fm
Clypeaster	2	Chattahoochee Fm
		Chipola Fm
Rhyncholampas	3	Arcadia Fm
		Chipola Fm
		Peace River Fm
Echinocyamus	1	Chipola Fm
Echinarachnius	1	Chipola Fm
Agassizia	1	Arcadia Fm
Brissopatagus	1	Chattahoochee Fm
Brissidae	1	Chipola Fm
Lovenia	1	Chattahoochee Fm
gen. indet.	1	Coosawhatchie Fm
CRINOIDS	none	
ASTEROIDS		
Astropectinidae	?	Arcadia Fm
		Chipola Fm
		Coosawhatchie Fm
		Parachucla Fm
OPHIUROIDS		
gen. indet.	?	Marks Head Fm

species have been located in samples from the Chipola Formation donated to the FLMNH by Emily and Harold Vokes. Two other formations (the Arcadia and Chattahoochee) have four and six different taxa (respectively), while the rest of the formations only have one or two species. Within the Miocene, a total of 19 taxa are present, with 11 of those as new taxonomic records. In addition, 16 new stratigraphic records for the state are presented herein. The Chattahoochee Formation shows the most change of the nine stratigraphic units containing echinoids, with six new stratigraphic records and five new taxa.

The Miocene has four taxa that are found in more than one stratigraphic unit. These include: Prionocidaris cookei Cutress (Chipola and Torreya formations), Abertella aberti (Arcadia, Coosawhatchie, and Peace River formations), Abertella sp. (Chipola, Coosawhatchie, and Torreya formations), and Rhyncholampas sp. (Arcadia and Peace River formations).

Pliocene Echinoids

The Pliocene echinoid record shows modest change with respect to the number of taxa hitherto known from Florida, but has a significant number of new stratigraphic records. Perhaps one reason for this is the significant urban development in the areas underlain by Pliocene sediments, especially in areas of south Florida. As excavation of land takes place, new (and typically temporary) pits are produced which expose fossiliferous strata for examination. This factor, along with stratigraphic nomenclature revisions, may have enhanced the

potential for additional taxa. Currently, I have identified 23 taxa from the Pliocene, with five regular (= 21.7%) and 18 irregular echinoids (= 78.3%).

Four genera of regulars are found in the Pliocene, including Lytechinus, Echinometra, and Eucidaris represented by a single species, and Arbacia potentially having up to four species (see Table 4-4). Preservation is relatively good in specimens of Lytechinus, Echinometra, and Arbacia. Specimens of the species Lytechinus variegatus (Lamarck) and Echinometra lucunter (Linnaeus) are very well-preserved, showing little diagenetic or compaction effects (Figure 3-19). However, all specimens of Pliocene Eucidaris tribuloides (Lamarck) collected thus far show extensive compaction and fragmentation (Figure 3-19).

At least nine genera (represented by up to 18 species) of irregular echinoids also are present. Most Pliocene genera are represented by only one or two species, but the clypeasteroids exhibit slightly greater diversity. The genus Clypeaster contains at least five species from four formations and Encope has two species from four formations. The other genera of irregular echinoids with more than one species include Rhyncholampas, Mellita, and Pericosmus, with each having two. Preservation of the irregular echinoids generally is good to excellent, though some beds have only fragmentary remains. Several species of these irregular echinoids can be found in high concentration locally. Examples of common and easily recognizable Pliocene echinoids from Florida include the mellitids Encope tamiamiensis Mansfield (Figures 3-27 and 3-29) and Mellita aclinensis Kier from the Tamiami Formation. These two species were found in such high concentrations in some locations that the tests were densely

imbricated (e.g., UF locality CH003, the former Lomax King Pit in Charlotte County).

The echinoids from the Pliocene are present in five formations (Figure 2-1) and have 23 taxa of regular and irregular echinoids (Table 4-4). The Tamiami Formation has the highest diversity of the stratigraphic units, with 12 taxa present. The Caloosahatchee Formation (seven species) and the Nashua Formation (up to six taxa) follow the Tamiami Formation in diversity, with the Intracoastal Formation containing three taxa. A large number of new stratigraphic records (15) of echinoids are reported herein and the unit with the largest number of new records is the Nashua Formation (five records). The Tamiami Formation also has a significant number of additions, with three new stratigraphic records. All formations in the Pliocene, except the Caloosahatchee, have new records of echinoids. Three formations have possible new species , but each are quite tentatively considered new at this time.

In the Pliocene, five species are found in more than one stratigraphic unit. These include: Lytechinus variegatus (Lamarck) (Caloosahatchee and Tamiami formations), Arbacia improcera (Conrad) (Tamiami and Jackson Bluff formations), Encope aberrans Martens (Caloosahatchee, Tamiami, and Intracoastal formations), Agassizia porifera (Ravenel) (Caloosahatchee and Tamiami formations), and Echinocardium orthonotum (Conrad) (Tamiami, Intracoastal, and Jackson Bluff formations).

Table 4-4. Pliocene echinoderms and formations from which they were collected.

GENUS	# OF TAXA	FORMATION(S)
ECHINOIDS		
Lytechinus	1	Caloosahatchee Fm
		Tamiami Fm
Echinometra	1	Caloosahatchee Fm
Arbacia	2	Nashua Fm
		Jackson Bluff Fm
		Tamiami Fm
Eucidaris	1	Tamiami Fm
Encope	2	Caloosahatchee Fm
		Intracoastal Fm
		Nashua Fm
		Jackson Bluff Fm
		Tamiami Fm
Mellita	2	Nashua Fm
		Tamiami Fm
Clypeaster	5	Caloosahatchee Fm
		Intracoastal Fm
		Nashua Fm
		Tamiami Fm
Rhyncholampas	2	Caloosahatchee Fm
		Tamiami Fm
Pericosmus	2	uncertain
Agassizia	1	Caloosahatchee Fm
		Tamiami Fm
Echinocardium	1	Intracoastal Fm
		Nashua Fm
		Jackson Bluff Fm
		Tamiami Fm
Plagiobrissus	1	Tamiami Fm
Brissidae	1	uncertain
CRINOIDS	none	
ASTEROIDS		
Heliaster	1	Tamiami Fm
Luidia	1	Tamiami Fm
Oreasteridae	?	Tamiami Fm
gen. indet.	?	Nashua Fm
OPHIUROIDS		
	?	Tamiami Fm

Pleistocene Echinoids

The Florida Pleistocene echinoid record has doubled since I began my work to update the echinoderm biostratigraphy in the early 1990's. The diversity now stands at six taxa, which is interesting not only due to the large proportional increase, but also because of the very low diversity overall during the epoch. The drop from the Pliocene to the Pleistocene is dramatic, even with my increased diversity values (Figure 4-2). Furthermore, the Pleistocene diversity is much lower than the 27 species known from the shallow water environments (<37 m) surrounding Florida today (Camp et al., 1998). The strata of the Pleistocene contain no regular and six irregular echinoids. This is the only epoch in Florida currently without any regular echinoids (Figure 4-1).

The irregular echinoids are represented by four genera (Table 4-5), with Encope and Clypeaster each having two species while Mellita and Moira have one species each. Preservation of echinoids in the Late Pleistocene units is relatively poor, but in Early Pleistocene formations the preservation is commonly better. This good preservation is obvious in species like Clypeaster rosaceus (Linnaeus), shown in Figure 3-35 of chapter 3. Many Pleistocene samples are fragmented and heavily abraded, which may reflect a high energy, near-shore depositional environment. In some cases, the samples have sedimentary rock and other fossils well-cemented to their surfaces, as in Encope michelini Agassiz (Figure 3-36), making them difficult to clean, prepare, and identify.

The Pleistocene echinoids are part of three formations in the state (Figure 2-1). The Bermont Formation has four taxa, the Anastasia Formation

Table 4-5. Pleistocene echinoderms and the formations from which the fossils were collected.

GENUS	# OF TAXA	FORMATION(S)
ECHINOIDS		
Encope	2	Anastasia Fm
		Bermont Fm
Mellita	1	Anastasia Fm
		Satilla Fm
Clypeaster	2	Bermont Fm
Moira	1	Bermont Fm
CRINOIDS	none	
ASTEROIDS		
gen. indet.	?	Bermont Fm
OPHIUROIDS	none	

two taxa, and the Satilla Formation one taxon. Four new stratigraphic records are found in the Pleistocene, with the Bermont Formation having two, and each of the other formations having one. Only one new taxonomic record resulted from my work, which was found in the Bermont Formation.

Finally, only one species is found in more than one formation during this epoch. The taxon is Mellita quinquiesperforata, and it is found in the Anastasia and Satilla formations.

Crinoids

The first report of Eocene comatulid crinoids in North America was by Emmons (1858), in which he described a new species, Microcrinus conoideus,

from the Eocene marls of North Carolina. A second crinoid worker, Gislén (1934), described the comatulid Himerometra bassleri from the Eocene of South Carolina. Howe (1942) published a discussion of Tertiary microfossils that he believed had been overlooked by Gulf Coast paleontologists, even though the fossils may be locally abundant. At the time, Howe was unable to find prior references to four classes of fossil echinoderms, including ophiuroids, comatulid crinoids, asteroids, and holothurians, from strata in the Gulf Coast region. He attributed the absence of studies on these fossil echinoderms to neglect by paleontologists, not a poor fossil record. Much work on fossil echinoderms, particularly fossil echinoids, has been completed in the nearly 60 years since Howe wrote his paper. Unfortunately, neglect apparently continues to plague the comatulid crinoids.

Oyen (1992) first reported the occurrence of H. bassleri in Florida from the Inglis Formation (Lower Ocala Limestone) in an abstract, and later published a detailed discussion of the biostratigraphic distribution of crinoids in Florida (Oyen, 1995). The most recent discussion of Tertiary comatulids from Florida, as well as other states in the southeastern U.S.A., was by Oyen and Perreault (1997). All the Coastal Plain states from Louisiana to North Carolina have records of comatulids, and states such as Georgia and Alabama have several different taxa, some of which prove to be common when microscopic fractions are examined closely (Oyen and Perreault, 1997; Oyen, unpublished data). Therefore, I believe it is likely that more taxa will be found to augment my currently reported comatulid diversity for the state of Florida.

The fossil crinoids from Florida consist of several different skeletal components from two taxa of comatulids (Table 4-1). The collection of H. bassleri consists of skeletal components including 50 centrodorsals, 53 radial plates, and 20 basal rays found at UF locality CI001 (UF 39054 - UF 39090) in Citrus County. Specimens are small, with most centrodorsals less than 10 mm in diameter, and the effects of diagenesis (recrystallized ossicles, epitaxial cements) are visible in many of the fossils. Figure 3-40, parts A-C show representative views of the dorsal and ventral surfaces of the centrodorsal, the included radial plates and basal rays for this species, as well as the imperfect preservation state of the crinoid components.

A second comatulid crinoid species from Holmes County, Florida was collected from the Upper Ocala Limestone. Skeletal components consist of five brachial plates and only one centrodorsal from UF locality HO001 (UF 48125 and UF 48126). Figure 3-40, D-G, show dorsal and ventral views of the centrodorsal and two representatives of the five brachial plates. These specimens are distinctly smaller than those of H. bassleri, with the centrodorsal measuring approximately 2.0 mm in diameter and the brachials averaging 1.0-1.5 mm in length. The taxonomic status of these specimens is still uncertain.

Asteroids

The record of asteroid taxa from the Cenozoic of Florida is rather limited, even though the abundance of skeletal fragments may be high in some strata. Most echinoderms disarticulate soon after death, but the asteroids seem

particularly susceptible to leaving a complex fossil record for paleontologists to decipher. Individual sea stars may have hundreds of ossicles that disperse readily following death in higher energy environments. Only if burial occurs rapidly at the time of death or shortly thereafter will the original morphologic arrangement remain intact. Records of asteroids exist from the Paleozoic through the Cenozoic, but in general, asteroids are rare and any well-preserved fossils are exceptional (Spencer and Wright, 1966).

Approximately 1,800 species of sea stars have been described from the world's oceans, with the richest diversity in reefs from the Red Sea and Indo-West Pacific (Hendler et al., 1995). They also report that the northern Caribbean and Gulf of Mexico have relatively low diversity, with only 18 species in the shallow depths of less than 46 m and another 160 species at depths down to 3658 m. Camp et al. (1998) compiled a list of shallow-water marine invertebrates from Florida's coast and reported 21 species of asteroids from the depth range of 0 to 37 m. The fossil record of asteroids from the Cenozoic of Florida is extremely limited in comparison with the modern faunal diversity. One of the reasons for the low fossil diversity simply is due to the difficulty in identifying lower taxonomic levels based on isolated ossicles.

Fossil asteroids in Florida are known from the Middle Eocene through the Pleistocene. Only one group of specimens from the Pliocene has been identified to species level, one Pliocene sample has been identified to genus level, while the rest of the fossils currently have been limited to tentative generic or familial identifications.

The Paleogene has records of asteroids from the Middle Eocene Avon Park Formation and the Late Eocene Ocala Limestone. A beautiful fauna associated with fossil seagrasses in the Avon Park (Ivany et al., 1990) contains juvenile echinoderms, including sea stars representing possibly Goniodiscaster, a member of the family Oreasteridae (Figure 3-40, H). This same taxon is represented by several adult specimens, both as articulated calcite ossicles and external molds, and as numerous isolated marginal ossicles from several Late Eocene exposures (Figure 3-40, I-J; Figure 3-41, A-B). Figure 3-42 A shows an example of a Recent Florida Oreaster reticulatus (Linnaeus, 1816) for comparison. Unfortunately, specimens normally are too poorly preserved to permit a more confident taxonomic identification. In the Oligocene, asteroid ossicles have been reported from the Suwannee and Bridgeboro limestones. Once again, no complete specimens exist (i.e., predominantly isolated ossicles), so the best interpretation is that these samples are skeletal components from one or more species belonging to the Oreasteridae.

Asteroid fossils and skeletal fragments are found throughout the Neogene as well. Several formations from the Miocene contain asteroid ossicles, all of which have been interpreted as possible representatives of the family Astropectinidae (see Figure 3-42, B-C for modern example). These ossicles are much smaller than the typical Paleogene sea star ossicles. Thus, they may be overlooked more easily, even by workers familiar with large marginal ossicles from the older rock units. Formations that have astropectinid ossicles include the

Arcadia, Coosawhatchie, Parachucla, and Chipola (where such ossicles are the most common).

The most spectacular preservation of fossil sea stars in Florida is found in the Pliocene. Jones and Portell (1988) described the occurrence of whole body asteroids, Heliaster microbrachius Xantus, from the Tamiami Formation in Charlotte County, Florida. This species has between 27 and 44 arms, and many of the individuals (of the approximately 360 total) are preserved complete with arms intact (Figure 3-43 A). The Tamiami Formation has two other taxa as well, with articulated ossicles of partial arms of Luidia sp. (Figure 3-43 B) and ossicles identified as a possible Oreasteridae. Another Pliocene formation with sea star skeletal debris is the Caloosahatchee Formation, which contains ossicles that await full identification. Finally, two Pleistocene stratigraphic units (Bermont and Nashua formations) have asteroid ossicles that have yet to be specifically identified.

Ophiuroids

Ophiuroids have a very poor fossil record in the Cenozoic of Florida. Like the sea stars, these organisms have many individual skeletal plates that disarticulate readily after death. The ossicles typically are very small (most are less than one mm in diameter), and are difficult to find without careful examination of the sedimentary rock. Furthermore, such isolated ossicles may be overlooked because they are unfamiliar to many paleontologists. Thus, the

paucity of fossil ophiuroids probably is an artifact of the sampling habits of paleontologists to a greater degree than a real lack of fossils.

The diversity of brittle stars in the modern oceans is estimated to be approximately 2,000 species (Hendler et al., 1995). Hendler et al. report ophiuroids associated with coral reefs in the Caribbean to be moderately abundant, and can be found in densities of 20 to 40 individuals per m^2. Burrowing species within soft sediment can be concentrated up to 100 times as dense as the reef species. In the shallow marine environment of Florida today, there are 65 species of ophiuroids at depths less than 37 m (Camp et al., 1998). Therefore, it would be reasonable to expect a much better fossil record of these organisms than I have found in Cenozoic strata of Florida.

There are only three formations with records of ophiuroids in the state. Ivany et al. (1990) reported complete external molds of juveniles found along the surface of fossil seagrass blades in the Eocene Avon Park Formation (Figure 3-40 H), but no identification of specific taxa was included in the paper. Ophiuroid vertebral ossicles also are found in the Miocene Marks Head Formation, but no lower taxonomic identification has been made for these fossils (Figure 3-43 C). Finally, a single complete specimen (Figure 3-43 D) associated with the asteroid Heliaster microbrachius is present in the Pliocene Tamiami Formation in southwestern Florida, but no specific taxonomic identification has been determined due to the specimen's recrystallization and imperfect preservation.

Biases in the Cenozoic Echinoderm Record

The pattern of echinoid diversity from the Middle Eocene through the Pleistocene is influenced by several variables. At this time, my echinoid data are much more detailed and thorough than the asteroid and ophiuroid data (both stratigraphic and taxonomic). Therefore, most of the following discussion will focus on the echinoids.

As noted in the taxonomic section, the echinoid diversity pattern now known from Florida has changed from previously published information. In particular, the diversity record in the Miocene has improved dramatically. In this section I will address how biases may be influencing the diversity pattern for echinoderms in Florida and possible reasons why the earlier data were relatively sparse for the Neogene (especially in the Miocene).

Resolution of Data

The data presented herein are at a relatively coarse level with respect to time units (epoch level resolution) and stratigraphic units (formation level resolution). Data have been gathered from publications, museum collections, and amateur and professional collectors. In some cases only locality information was provided, and depending on my knowledge of the locality and any associated quarries at the locality, I can determine stratigraphic unit(s) associated with the locality. I have been very conservative and cautious regarding these data derived from outside my personal work, and any

questionable stratigraphic assignments have been omitted from this database until better stratigraphic control can be established.

A second stratigraphic-control problem that limits resolution of data to formations only is that samples may have been collected from spoil piles. Therefore, exact stratigraphic position cannot be determined for those specimens and only the formation can be assigned to these specimens. Knowledge of the pit depth, mining depth for specific spoil piles, observations of sections during excavations, and discussions with quarry operators all are taken into consideration before assigning stratigraphic information to echinoid samples used in this study. Relatively few published records of echinoids and their stratigraphic position exist; therefore, the resolution for general patterns is limited to presence or absence in specific formations.

Stratigraphic Nomenclature

One of the greatest difficulties in geologic work in Florida involves distinguishing unique stratigraphic units according to the guidelines of the North American Stratigraphic Code. In many cases, only subtle variations in lithology exist among the state's Cenozoic strata (in contrast to non-Coastal Plain areas), which makes defining formations a challenge. A second inherent problem in the stratigraphic nomenclature of Florida has been the reliance on fossils to define formations. Examination of the literature involving names and definitions for several Cenozoic units shows that faunal constituents were the primary basis for identifying these formations. Unfortunately, much of the original work was done

prior to development of formal stratigraphic codes or guidelines and these formations have become strongly entrenched in the literature. Examples include the formations of the Eocene Ocala Group (i.e., Inglis, Williston, and Crystal River formations), which are now all part of the Ocala Limestone, and some Pliocene units such as the Caloosahatchee and Nashua formations. This type of nomenclature influence could be present in varying degrees from the Eocene through the Pleistocene. Thus, readers must be aware that such information is, in part, a function of the interpretations of lithostratigraphers, sedimentologists, biostratigraphers, and paleontologists to find geologically sound and functional solutions to the stratigraphic nomenclature difficulties in the state.

Outcrop Exposure and Relief

Another bias in the echinoderm data is a function of outcrop exposure. It is obvious that formations which have only limited surface exposure will have less geologic and paleontologic data readily available to gather during fieldwork. In Florida, only rocks from the Middle Eocene through the Pleistocene are exposed at the surface, and rocks from each epoch are represented by unequal proportions of surface exposure. This means that some epochs are less likely to be sampled. Furthermore, even when exposed, accessibility to some outcrops can be extremely difficult. For example, in the panhandle region where the Intracoastal Formation outcrops, very few roads exist, and those that do consist of narrow, dirt logging roads through rough, undeveloped areas.

A second aspect of collecting availability is the dependence on quarrying operations. Several mines have provided access for paleontologists and collectors. As a result, some stratigraphic units that may not be exposed directly on the surface may be exposed in the shallow subsurface following mine excavations. This allows fossils to be collected from areas where a given formation may not be represented on a geologic map for the area.

Perhaps just as important is the bias associated with the collectors of fossils themselves. Most collectors fall into two categories: "fossil shellers" or "bone hunters". Therefore, these collector groups tend to have a relatively narrow range of taxonomic focus. Shellers focus primarily on the mollusks while the bone hunters look for vertebrate remains. Other taxonomic groups such as the echinoderms, arthropods, and cnidaria have had a relatively low priority among these collectors, and therefore fewer specimens have been added to museum collections. This trend seems to be changing (specifically, it is improving) as more collectors are informed of the need for such fossil taxa by museums and paleontologists.

One of the rock exposure artifacts that also may help explain the large increase in Neogene taxonomic and stratigraphic records is the increasing population growth in Florida. As development and construction occur in the fast-growing areas along the coasts and in south Florida, more land is excavated for buildings, highways, utilities, and other infrastructure needs. These excavations provide opportunities to examine sedimentary rocks that simply were unavailable prior to development activities. On occasion, these temporary pits have exposed

units containing rare fossils such as the sea stars, Heliaster microbrachius (Figure 3-41).

Finally, another factor in contributing to bias regarding exposure of units is the general topography of the state. Florida has limited relief, with the highest point in the state just 104 m above sea level (Schmidt, 1997). South Florida, in particular, has a maximum topographic variation of less than about 7.5 m, and averages only a few meters locally. Strata tend to be relatively flat-lying and, therefore, only the top stratigraphic unit will be exposed unless excavation beneath the surface unit is completed. In addition, many areas of south Florida are covered with heavy vegetation, swamps, and marshes, which further reduce outcrop exposure in the area. Lack of surface outcrops is not limited to south Florida, however, and even though relief may be greater in the northern peninsula and panhandle areas it still is limited in comparison to non-Coastal Plain terrain. Overall, the Neogene units (found in lower relief areas) appear more likely to have suffered from lack of outcrop exposure than the Paleogene units due to these factors.

Carbonate Versus Siliciclastic Environments

Yet another bias in the echinoderm record may be related to the preservation potential for fossils in carbonate versus those in siliciclastic facies. My study has no experimental evidence to quantify this proposal, but personal observations of fossils in outcrop and in museum collections generally show that less abrasion and fragmentation of specimens is present in the carbonate rocks

in contrast to the fossils found in siliciclastic sedimentary rocks. Florida's non-carbonate rocks are dominated by quartz sands, with lesser amounts of phosphate grains, heavy minerals (such as ilmenite or rutile), and clay minerals. Does the high content of abrasive minerals (i.e., quartz) have a significant impact on the quality of preservation in fossils? Are softer and less durable carbonate minerals (i.e., calcite and aragonite) less likely to create deleterious effects on the skeletal components within the sediment that produces a sedimentary rock? It seems logical those questions can be answered affirmatively, but the answers probably are not so simple.

Chave (1964) published one of the first papers on skeletal durability and preservation potential, in which he tumbled skeletal material in a rock tumbling barrel using various abrasives to provide durability estimates. Chave's study used a variety of taxa for the experiment, including the regular echinoid Strongylocentrotus and the sea star Pisaster, as well as mollusks, coral, algae, and bryozoans. Chave varied the type of sediment included in the tumblers with the skeletal material, among chert pebbles, sand grains, and skeletal parts only. His results showed that the siliceous chert and sand particles produced subequal abrasion and degradation results, and both produced more effective degradation than when only the carbonate shell materials were impacting one another in the tumblers. One of the more important conclusions of his study, however, was not that siliceous grains are more detrimental to fossil preservation than skeletal grains, but, instead, skeletal microarchitecture is the most critical factor in determining the rate of degradation. Unfortunately, this does not answer my

questions regarding physical degradation and its relationship to sediment composition since Chave's experiment was not run using carbonate sediment as an abrasive.

Taphonomy of echinoderms has been discussed by a number of workers in recent years, including Schäfer (1972), Kidwell and Baumiller (1990), Allison (1990), Donovan (1991), and Greenstein (1991, 1992, 1993). Detailed discussions of preservation and processes are included in these works, but none has specifically addressed differences in carbonate and clastic environments with respect to echinoderm preservation potential.

Research on foraminiferal taphonomy by Kotler et al. (1992) integrated both physical and chemical tests to determine preservation styles and processes for the microorganisms. Biogenic carbonate sands were used as the primary abrasive agent while quartz sands were used only as a matrix to identify post-mortem transport of the forams. This work produced slightly different results compared with abrasion tests done by other workers using siliciclastic sediment. For example, Chave (1964) found skeletal architecture to be important in differentiating exposure effects among selected macroinvertebrate taxa, whereas Kotler et al. (1992) found only limited variation in abrasion resistance among the microinvertebrate foraminifera that may be attributed to skeletal architecture. Their results showed that other factors including test hydraulic behavior, low traction velocity, and test shape, have discernable effects on abrasion susceptibility. Comparative observations of Florida echinoid fossils from the Paleogene and Neogene units suggest that abrasion is not the most important

taphonomic variable of concern. Instead, the overall preservation state of the echinoids, which includes the extent of fragmentation, chemical alteration (particularly dissolution), as well as abrasion, is better for the carbonate-dominated Paleogene formations, and poorer in siliciclastic-dominated Neogene formations.

Several reasons why carbonate and siliciclastic environments produce different fossil preservation styles were reviewed in Kotler et al. (1992), and may be applicable to Florida material. Carbonate beds or shell-rich clastic beds tend to produce a favorable chemical environment by buffering pore fluid against dissolution processes (Kidwell, 1989), while siliciclastic units with minimal carbonate shell content are more susceptible to dissolution. Rates of dissolution in terrigenous environments also are influenced by sedimentation rate, shell input, organic matter, and bioturbation (Meldahl, 1987). Furthermore, rate and consistency of sedimentation differ between carbonate and siliciclastic (terrigenous) environments, with long-term carbonate deposition typically slower than long-term terrigenous clastic deposition (Schindel, 1980). A combination of these factors would influence the preservation potential of calcareous shells, and the resulting differential preservation produced in carbonate versus siliciclastic regimes in turn would affect the diagenetic potential (i.e., alteration) that the fossil assemblage would undergo after burial (Kotler et al., 1992).

Details regarding skeletal breakdown in carbonate versus siliciclastic environments are extremely limited; thus, I may only speculate on the depositional environment's influence on the echinoderm record of Florida.

However, such a pattern is observable in my data, with the Neogene units showing distinctly larger increases in taxonomic and stratigraphic records in contrast to Paleogene units. Therefore, I believe this has contributed to a diversity bias, which I am addressing in this work.

Age of Stratigraphic Units

Age determination of stratigraphic units also will affect the echinoderm diversity pattern for the Cenozoic of Florida. I have not attempted to present information regarding absolute ages for the formations discussed in this study, and there are significant uncertainties. The Caloosahatchee and Nashua formations, for example, are mapped as Plio-Pleistocene in age but I have treated the echinoids found within these formations as being Pliocene. In reality, these formations are Plio-Pleistocene units, with the upper beds of the units Pleistocene in age. I do not believe that these formations are restricted to only one epoch, but have chosen the single epoch which best represents the age of the echinoids found within those formations. Clearly, taxonomic diversity per epoch will change as age assignments of formations change, since my data are constrained by formation-level resolution.

Epoch Duration

One aspect of the Florida echinoid diversity pattern that is important to note is the influence of time variation for my epoch resolution data. My data are limited to epoch assignment, where each epoch is unequal in duration.

Therefore, even though the number of known taxa from each epoch varies from a minimum of six species in the Pleistocene to a maximum of 38 species in the Eocene, these data can be standardized to help minimize the temporal duration effect. Kier (1977), McKinney et al. (1992), and Donovan (1993) standardized echinoid diversity values by dividing the diversity by the epoch duration (in millions of years), and herein I follow this style as well.

The Avon Park Formation is the oldest unit at the surface in Florida and the oldest unit containing echinoids. The age of the Avon Park is late Middle Eocene (Puri and Vernon, 1964), which I assume to represent the base of the Bartonian Stage at approximately 42.1 Ma (Harland et al., 1990). Using epoch boundary ages provided in Harland et al., the duration of each of the epochs was calculated and used to determine diversity values normalized by millions of years of duration. Since the age of the Avon Park is only an estimate, the normalized diversity may be slightly skewed, but it is at least a reasonable estimate to use for comparative purposes. The results of the calculations are provided in Table 4-6.

Following time normalization, the pattern of echinoid diversity from the late Middle Eocene through Pleistocene changes noticeably in two areas. First, the Miocene diversity no longer is above average, but instead is nearly the lowest of the intervals examined. Second, the Pleistocene diversity changes from the lowest diversity interval to one of the highest diversity intervals (due to the very short duration of the epoch). As a result, the normalized Florida data (Figure 4-3) do not match normalized worldwide echinoid data because the Miocene diversity

Table 4-6. Normalized Florida echinoid diversity. Total echinoid diversity for each epoch is divided by the duration of the epoch to produce normalized diversity values (in number of species per million years [Ma]). Epoch duration values were calculated from data in Harland et al. (1990).

EPOCH	EPOCH LENGTH (Ma)	ECHINOID TAXA TOTAL	NORMALIZED DIVERSITY
Pleistocene	1.63	6	3.68
Pliocene	3.56	23	6.46
Miocene	18.10	22	1.22
Oligocene	12.10	11	0.91
Eocene	6.70	38	5.67

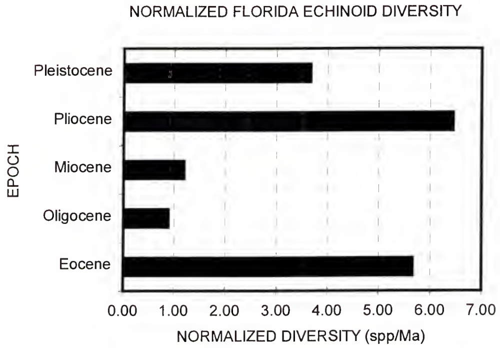


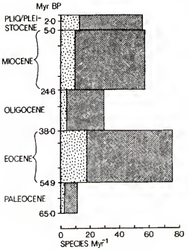
Figure 4-3. Normalized Florida echinoid diversity for species from the Middle Eocene through Pleistocene. Note the proportionally low normalized diversity for the Miocene and proportionally high diversity for the Pleistocene. This is in obvious contrast to the raw diversity pattern illustrated in Figure 4-1.

of Florida is proportionally low whereas the worldwide diversity is proportionally high (Figure 4-4 A). Alternatively, the Florida diversity closely follows the pattern found in the Cenozoic of Jamaica (Figure 4-4 B).

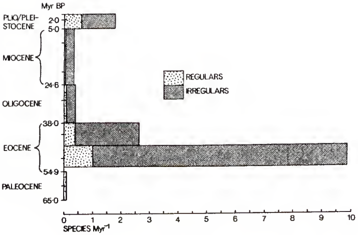
Donovan's most recent diversity data for Jamaica (Donovan, in press), which includes both published and unpublished sources, has a slightly higher normalized diversity for the Oligocene than my records show in Florida. However, the general pattern of lower than average diversities for the Late Paleogene (Oligocene) and Early Neogene (Miocene) is found in both regions of the Caribbean. The correspondence of Jamaica and Florida diversities likely suggests a regional divergence from the worldwide Miocene diversity increase, which may be due to sustained unfavorable environmental conditions in the Caribbean following the Eocene epoch.

Taxonomic Nomenclature

Taxonomic descriptions of fossil echinoderms in Florida are predominantly at the specific level, with few subspecies recognized. For the echinoids, published data show less than ten subspecies have been reported from the Cenozoic. I have taken a conservative approach for this study and omitted all subspecies from my "taxonomic records" count for all epochs. I believe closer examination of these taxa will show most or all such subspecies to be taxonomically invalid. Therefore, inclusion of subspecies only results in the inflation of taxonomic diversity for the Eocene, Pliocene, and Pleistocene epochs where such taxa are found. An example of possible echinoid taxonomic splitting



A)



B)

Figure 4-4. Comparison of normalized diversity values. A) Worldwide normalized diversity of fossil echinoid species in the Cenozoic using data from Kier (1977). B) Normalized diversity of Cenozoic species from Jamaica. (Modified from McKinney et al., 1992)

is that of the clypeasteroids in the Pleistocene Bermont Formation, Clypeaster rosaceus (Linnaeus) and Clypeaster rosaceus dalli (Twitchell). This dissertation is not designed to formally revise echinoderm taxonomy, but it should be noted that the number of taxonomic records included in my values for the Pleistocene has only one record for C. rosaceus from the Bermont Formation rather than two. Additional research is continuing on taxonomy of Florida echinoids (by C. Oyen and R. Portell), crinoids (by C. Oyen), and asteroids and ophiuroids (by D. Jones and Portell), and the validity of various subspecific assignments will be considered in future work.

A second taxonomic problem for biostratigraphy of echinoids in the southeastern U.S.A., is the geographic effect on taxonomy. Similar echinoids from different geographic areas have been called different species, even though the specimens are not sufficiently distinct to justify a split. For example, Arbacia crenulata Kier from the Tamiami Formation in Florida and A. improcera (Conrad) of the Yorktown Formation of Virginia and North Carolina, as well as the Croatan Formation of North Carolina, are found in different geographic areas, and therefore were described as different species. It has been noted subsequently that splitting these age-equivalent taxa into unique species is not valid, since further examination of specimens shows no significant morphological variation that would allow defining two distinct species (Kier, 1972). Fortunately for my work in Florida, such geographic-based taxonomic splitting has little to no impact on the Florida echinoid diversity because only one or two species, of those which may have this effect, were counted in my taxonomic records.

Collector Bias

One of the biases of the fossil record that affects most taxonomic groups, including the echinoderms, is the tendency for people to collect clean, unbroken, and larger sized (that is, more obvious) fossils. Clearly, not all researchers have this style of sampling bias, but it often requires conscious effort to include incomplete specimens, small fragments, moldic samples, or bags of matrix for microfossil analyses. While it becomes more difficult to identify lower taxonomic levels from isolated skeletal components, such fragments can at least provide some data for paleoecology interpretations. This has been noted in echinoid taphonomy and paleoecology research by several workers, including Gordon and Donovan (1992), Greenstein (1993), Kidwell and Baumiller (1990), and Nebelsick (1992).

The Miocene epoch has the greatest increase in stratigraphic and taxonomic records of echinoids in Florida. One of the reasons this is true is because it is not common to find complete, well-preserved echinoids in Miocene strata. Several of the new records I include in this paper are derived from test fragments, spines, or molds, rather than nearly complete tests. An example of the moldic preservation style is found in Lovenia clarki from the Chattahoochee Formation (Figure 3-18), and silica rubber peels are often made of the mold in order to more detailed descriptive work. In some stratigraphic units these fragments are not uncommon, but probably were ignored because of the difficulty in sorting and identifying such skeletal parts to family, genus, or species levels. Furthermore, some of the fragments are relatively small and may be found only if

one examines the fine fractions of sediment in section or in spoil piles. This bias is not limited to the Miocene units but seems to be proportionally less prevalent in other portions of the Cenozoic of Florida.

One excellent example of how to avoid such biases by careful examination and collection of microfossils and incomplete specimens is that of Harold and Emily Vokes (Tulane University). When collecting the numerous Chipola Formation localities in northern Florida (along Tenmile Creek, Farley Creek, and the Chipola River), they and their associates would not only collect the taxonomic groups they were interested in personally, but also anything else of either micro- or macro-size. It is because of their comprehensive collecting, washing and sorting, that I can confidently make statements about echinoderms like Prionocidaris being a common and abundant fossil occurring in the Chipola Formation, even though the Vokes' focused their research on mollusks rather than echinoderms.

Substrate and Facies Preferences of Echinoids

Echinoids are now known from nearly all habitats ranging from intertidal to deep marine, and from tropical to polar regions in all oceans throughout the world. Although a few species have nearly cosmopolitan distribution, most are geographically restricted and, even further, are habitat limited in distribution (Smith, 1984). Ernst Mayr (1954) described numerous ways the geographic distribution of echinoids is controlled. Mayr believed the most influential controls of echinoid species global distribution to be the presence of land barriers, wide

ocean basins, and oceanic current patterns. However, even within small geographic regions, species distribution is patchy, rather than continuous (Smith, 1984). This non-continuous distribution is easily observed in the fossil record of echinoids in Florida strata, and thereby warrants a brief discussion of this pattern.

In general, there are multiple controlling factors for the irregular distribution of echinoid species. The studies by Kier and Grant (1965), Ebert (1971), and Smith (1984) have defined eight factors. These controls include the substratum, hydrodynamic regime, predation, salinity, temperature, food availability, water depth, species behavior, and chance. Of these factors, the nature of the substrate (specifically, the physical characteristics including the grain size, sediment stability, degree of sorting, content of organic matter, porosity, and permeability) is most influential on local distributions (Smith, 1984).

Sedimentary facies are defined by the physical characteristics of the sediment that indicate environmental conditions at the time of deposition. Individual species of echinoids have well-defined preferences for specific substrate characteristics; therefore, the presence of a given echinoid species may serve as a proxy indicator of a sedimentary facies for those paleontologists who have not examined the sedimentary rock that contained the fossils. Zoologists studying modern taxa have described the close relationship of taxa with specific substrate characteristics. One example is the research completed by McNulty et al. (1962) in which they examined the distribution of echinoids in the shallow water region of southern Florida. They found the spatangoid Moira atropos (a species first reported as a fossil from Florida in this dissertation) was

found only in sediments consisting of 75-90% sand-sized particles with 0-12% gravel and 10-20% silt, while mellitid species live only in medium- to fine-grained sands. Similar correlations between modern species and substrate characteristics have been reported for both regular and irregular echinoids by Lawrence and Ferber (1971), Heatfield (1965), and Smith (1980). Such a concept may prove to be a useful tool for sedimentary petrologists, stratigraphers, and paleontologists alike, because museum collections of echinoids that have associated stratigraphic and geographic information associated with their fossil echinoids can then be used to produce general facies distribution maps. I have included examples of such interpretations for selected Florida species in subsequent text and figures.

Analyses of substrate preferences for a variety of Paleogene echinoids from the southeastern U.S. and other regions worldwide have been completed in the last dozen years. Burchard Carter of Georgia Southwestern State University has lead several such projects that have included fossils collected from Florida or species in nearby states that are also part of the fossil record in Florida (see Carter, 1989; Carter et al., 1989; Carter, 1990; Carter and McKinney, 1992; Carter, 1997). As part of his research, Carter produced thin-sections of both the limestones and the echinoid tests (with sediment still trapped within the internal cavity of the test) for determination of grain size of the substrate. He found consistent patterns among the irregular echinoids that allowed him to identify substrate preferences for specific and/or generic levels of taxa.

Two of the publications that resulted from this work, Carter et al. (1989) and Carter (1990), indicated species that were identified as dominantly inhabiting one (or rarely, two) of the three qualitative categories of carbonate substrates termed clean sand, muddy sand, or very muddy sand. As an example, all three species of Oligopygus (O. phelani, O. haldemani, and O. wetherbyi) were determined to be abundant or common in clean sand substrates (see figure 1 in Carter, 1990, for a complete listing of taxa and substrate preferences). All Eocene species of Rhyncholampas also fall into the clean sand dweller category, while other species such as Eupatagus ocalanus and Wythella eldridgei are muddy sand dwellers. Those species that occupy the very muddy sand category include Brissopsis steinhatchee and Eurhodia patelliformis, among others. These results are used as the primary guide for my projections of facies distributions via echinoid presence, although my own observations of facies preferences by particular echinoid species also correlate well with the data gathered by Carter and his co-workers. The work completed by Carter and others is limited, however, to the Late Eocene formations of Florida (using the Ocala Group stratigraphic nomenclature rather than the Ocala Limestone). Therefore, I have extrapolated those interpretations to include closely related echinoid taxa for the rest of the Cenozoic epochs based upon my field observations of both fossil and modern species from Florida and the shallow marine coastal areas.

To illustrate the use of echinoids as sedimentary facies proxies, I have identified at least one or two species from the Eocene through Pleistocene

epochs to use as sand facies indicators. These species then are used to graphically display areal distribution of sand facies units within a given formation in the state of Florida. One limitation of this approach using my data should be noted, however. All data are limited to county level resolution for my areal maps. In reality, sand facies within a given formation often are far more limited, both laterally and stratigraphically, than would be indicated by my maps. The goal of these illustrations is to show the future value of using the echinoids as a tool, but recognizing further data must be gathered to fully accomplish this goal. As noted in earlier chapters, much of the stratigraphic data for the echinoids are limited to formation level only. Until stratigraphic sections are measured and specific geographic data such as latitude and longitude are included, these interpretations should be regarded as only a first attempt to apply the echinoid distribution data to other geologic research, such as sedimentary geology. The echinoids chosen to illustrate sand facies distribution throughout the state over time include: 1) Oligopygus wetherbyi and Rhyncholampas ericsoni for the Ocala Limestone of the Eocene (Figure 4-5); 2) Rhyncholampas gouldii for the Suwannee Limestone of the Oligocene (Figure 4-6); 3) Abertella aberti for the Arcadia Formation of the Miocene (Figure 4-6); 4) Encope tamiamiensis for the Tamiami Formation and Rhyncholampas ayresi for the Caloosahatchee Formation of the Pliocene (Figure 4-7); and 5) Clypeaster rosaceous for the Bermont Formation and Mellita quinquiesperforata for the Satilla Formation of the Pleistocene (Figure 4-8). A common theme in these taxa is that all are members of one of the orders of cassiduloids, oligopygoids, or clypeasteroids. Species of

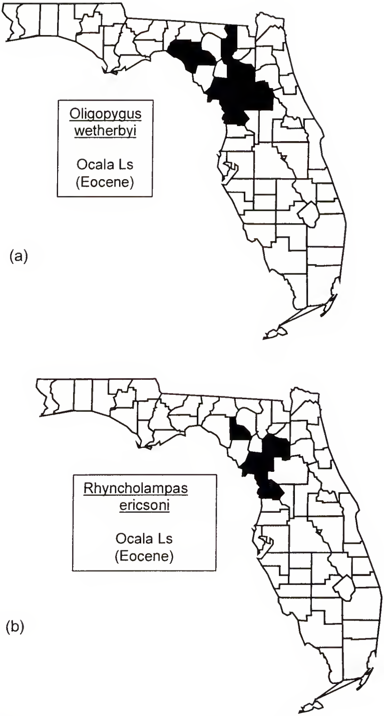


Figure 4-5. Eocene echinoids as carbonate sand facies distribution indicators. (a) Areal distribution of carbonate sand facies in the Ocala Limestone as indicated by Oligopygus wetherbyi. (b) Areal distribution of carbonate sand facies in the Ocala Limestone as indicated by Rhyncholampas ericsoni.

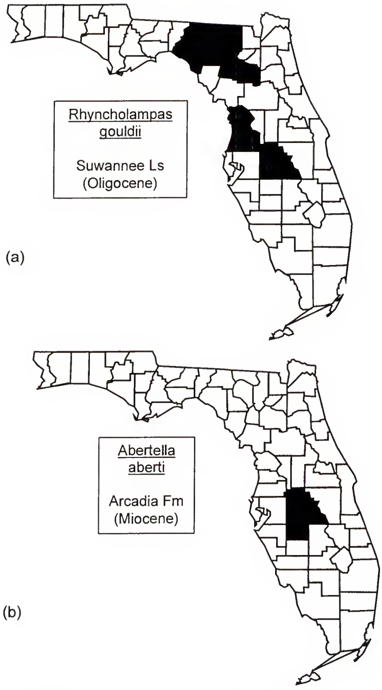


Figure 4-6. Echinoids as carbonate sand facies distribution indicators. (a) Areal distribution of carbonate sand facies in the Oligocene Suwannee Limestone as indicated by Rhyncholampas gouldii. (b) Areal distribution of carbonate sand facies in the Miocene Arcadia Formation as indicated by Abertella aberti.

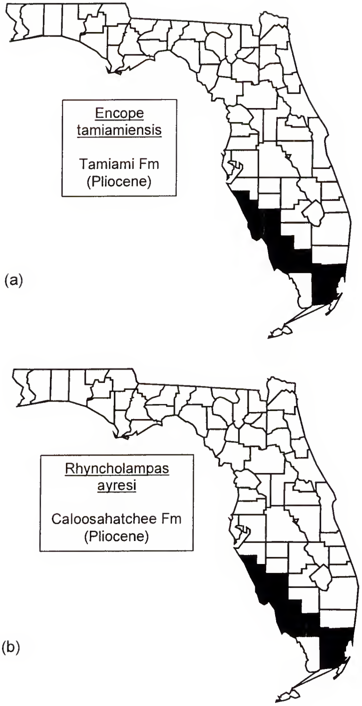
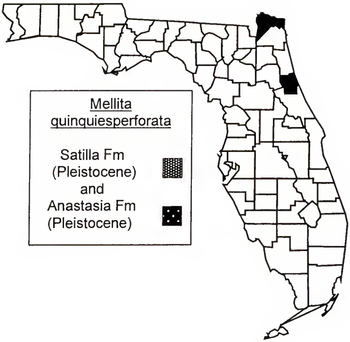
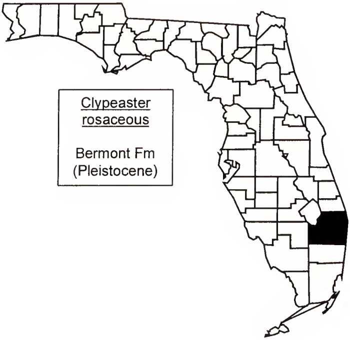


Figure 4-7. Pliocene echinoids as sand facies distribution indicators. (a) Areal distribution of sand facies in the Tamiami Formation as indicated by Encope tamiamiensis. (b) Areal distribution of sand facies in the Caloosahatchee Formation as indicated by Rhyncholampas ayresi.



(a)



(b)

Figure 4-8. Pleistocene echinoids as sand facies distribution indicators. (a) Areal distribution of sand facies in the Anastasia and Satilla formations as indicated by Mellita quinquiesperforata. (b) Areal distribution of sand facies in the Bermont Formation as indicated by Clypeaster rosaceous.

these orders, in turn, share similar habitat preferences, only one of which is substrate characteristics. In some circumstances, these fossils are not exceptionally abundant within each of these formations, but they are at least not rare within the units and thereby would allow a reasonable likelihood of recovery during fieldwork so they may be applied to facies distribution interpretations.

In summary, the substrate preference of given species of echinoids will not only influence their geographic distribution throughout the state, but the presence or absence of a given facies will also ultimately control the abundance and potential diversity of echinoids during a given time. Therefore, the diversity pattern present from the middle Eocene through the Pleistocene is influenced in part by the depositional environment and facies that existed at any given time.

The Eocene-Oligocene Diversity Change

Several significant changes occurred in the world's oceans in the middle Paleogene which are readily identified based on sedimentation patterns, isotopic studies of various fossil taxa, and paleobiogeographic patterns. In particular, paleobiogeographic patterns reflect distribution changes for fossil taxa that, in turn, reflect the change in environmental conditions present in the water masses. Extinction of various taxonomic groups also is associated with the Eocene-Oligocene boundary and was extensive enough to be noted slightly above background extinction rates. However, it was not as pervasive as extinction levels at other times such as the Permian-Triassic and Cretaceous-Tertiary boundary events (see Raup and Sepkoski, 1982 and 1986).

The extinction event at the Eocene-Oligocene boundary was called the "terminal Eocene event" by Wolfe (1978), who noted significant changes in terrestrial plant biogeographic distributions as well as in global temperature patterns. Temperature change (cooling) in the late Eocene has been noted in marine taxa both by faunal assemblage shifts from warm to cool water taxa dominance as well as isotopic shifts in ^{18}O. Specifically, these changes can be seen in benthic foraminifera (Buchardt, 1978; Corliss, 1979; Keigwin, 1980; Keigwin and Corliss, 1986), planktonic foraminifera (Berggren, 1977; Keller, 1983 and 1986; Boersma, 1987), ostracodes (Benson et al., 1984), molluscs (Hansen, 1987), and echinoids (McKinney and Oyen, 1989; McKinney et al., 1992). Evidence for dramatic climatic change (specifically, temperature drop) is also supported by extinction of terrestrial vertebrate groups at the end of the Eocene (Prothero, 1985).

Changes in various marine invertebrate taxa as well as the proposed forces for the change are discussed in the following paragraphs. The influence of temperature change, tectonic activity, development of the psychrosphere, sea level change, and high latitude glacial buildups are all important interrelated factors that had an effect on faunal shifts and extinctions in the marine realm near the end of the Eocene. Thus, the significant diversity drop in Florida echinoids (shown earlier in this chapter) may be controlled by one or more of these changes taking place in the Paleogene.

Early Paleogene Oceanographic Conditions

The early to middle Paleogene oceans represent a transition from thermospheric circulation to predominately thermohaline circulation as latitudinal temperature gradients gradually increased (Haq, 1981). This thermal gradient is a function of increased cooling in high latitude regions while low latitudes maintained a reasonably stable temperature regime. Although the forces driving circulation were beginning to change, during the Paleocene the world's oceans were still dominated by patterns established in the Cretaceous. These include the paleo-Gulf Stream flowing northward and the continuous equatorial current of the Tethys Seaway that dominated tropical circulation with westward flow (Haq, 1981). This represented the major flow path for inter-oceanic circulation connecting the Indo-Pacific and Atlantic-Pacific oceans (Kennett, 1982).

The thermospheric circulation (Cretaceous) that established the currents for the early Paleogene was based on a system without as strong of a thermal gradient between equatorial and polar latitudes. Further, the vertical thermal gradient in the oceans was less at the beginning of the Paleogene (Haq, 1981), thereby suggesting that both surface and deep water circulation was sluggish in comparison with the late Paleocene to early Eocene thermohaline circulation.

Land mass arrangement was much different at the beginning of the Paleocene than at the end of the Eocene, and this played a critical part in circulation and temperature/climate patterns. Antarctica, South America, and Australia were still joined and concentrated in the Southern Ocean over the polar

region, but this arrangement had been altered tectonically by the late Eocene and represents a critical event in Cenozoic paleoceanography (Kennett, 1977).

Early To Middle Paleogene Transitions

Kennett (1977) described several important changes in the paleoceanographic characteristics during the Cenozoic. These major changes influenced not only the climatic traits of the earth but also affected the biota associated with the oceans. Changes include: 1.) Separation of Australia and South America from Antarctica allowing development of the circum-Antarctic Current, 2.) Disturbance of the equatorial Tethyan Seaway, and 3.) Development and interaction of high latitude bottom waters as a result of climatic and glacial events in those regions.

At the beginning of the Paleocene, the Antarctic continent (including still-attached Australia) was located in a polar position with no significant glacial ice coverage and both shallow and deep waters were relatively warm (Kennett, 1982). The north polar latitude Arctic Ocean was closed in both by the Atlantic and Pacific Oceans, thereby closing off cold bottom water connections in the northern high latitudes. Kennett (1982) notes that this partial isolation of bottom waters caused geochemical variations in the world oceans such as the carbonate compensation depth (CCD) rising through the early and middle Paleogene in the Pacific, while lowering during the same time in the Atlantic. Haq (1981) suggested the Paleogene tectonic conditions reduced the northern area in the Pacific, resulting in an increased importance of the southern high latitudes as a

source area for deep waters for the Indian and Atlantic Oceans in the middle and late Tertiary.

Haq (1981) cited several important changes through the Paleogene in addition to those given by Kennett (1977). Prior to the beginning of separation of Antarctica and Australia, separation of Greenland and Scandinavia began in the northern hemisphere, which in turn initiated the formation of the Greenland-Norwegian Sea. This did not significantly affect circulation patterns in the oceans during the early Paleogene, but by the middle Paleogene a surface water exchange with the Atlantic was established. The Greenland-Iceland-Faroe Ridge system that had previously blocked water exchange is believed to have subsided enough by the latest Eocene to exchange cold, dense water into the Atlantic (Haq, 1981). However, significant outflow of North Atlantic Deep Water (NADW) was not achieved until after the Paleogene, when subsidence of the Greenland-Iceland-Faroe Ridge had progressed further.

The late Eocene also was a time in which Tethyan circulation was beginning to be restricted somewhat in the northern Indian Ocean as India migrated toward Asia (Kennett, 1982). This was not a dramatic constraint on the current flow however, and likely only represents a minor oceanographic change at the end of the Paleogene.

Perhaps the most important oceanographic change to take place in the Paleogene is the tectonic separation of Australia from Antarctica. During the Paleocene, the Australia-Antarctica continent was in a polar position (Kennett, 1977) but during the early to middle Eocene, Australia began to migrate

northward creating an ocean between the two continents (Haq, 1981; Kennett, 1982). The impact of this separation was not realized in the world's oceans immediately because only very restricted circulation surrounding Antarctica was permitted due to the presence of the South Tasman Rise and the not yet open Drake Passage.

By the late Eocene (~40 Ma), a shallow water connection between the Indian and Pacific Oceans had been established after the South Tasman Rise had subsided (Kennett, 1977; Haq, 1981). This is an influential factor in the circulation patterns of the oceans because it initiated the establishment of the circum-Antarctic Current. Although the circum-Antarctic Current was not fully developed until the opening of the Drake Passage was complete sometime in the Oligocene (~38-30 Ma [Kennett, 1977 and 1982; Haq, 1981]), its influence was felt as early as 40 Ma.

The greatest effect of the isolation of Antarctica was the thermal change in ocean waters, initially cooling the surface waters and later causing a drop in bottom water temperatures. Kennett (1982) describes surface water temperature drops of 10° C from the early Eocene (at 20° C) to the late Eocene (at 10° C). Haq (1981) noted that this cooling was significant enough to cause large-scale freezing at sea level near Antarctica, and by the end of the Eocene (38 Ma), the initiation of production of Antarctic Bottom Water (AABW).

Another important feature associated with the cooling of surface and, in particular, bottom waters is the development of the pyschrosphere and the modern two-layered ocean. Benson (1975) first described this event as

occurring at approximately 40 Ma based on a cold bottom layer psychrospheric benthic ostracode fauna. Therefore, this marks the beginning of thermohaline dominant circulation as is present in the modern oceans (Kennett, 1977), versus thermospheric circulation as was present in the Cretaceous and much of the Paleogene. It is important to note that while many workers would describe the terminal Eocene event as the most significant paleoceanographic change in the Cenozoic (Kennett, 1982), the biotic crises may not actually reflect event(s) occurring at the Eocene-Oligocene boundary. In fact, when dealing with fauna having higher stratigraphic resolution (such as foraminifera), it has been demonstrated that extinctions and paleobiogeographic patterns are less instantaneous and more step-wise in nature than previously believed.

Late Eocene Extinctions and Biogeographic Patterns

Extinction of living plant and animal species is a process that has operated since life evolved on earth more than three billion years ago. It is a process that is of interest to scientists besides just paleontologists because the evolutionary process can provide important clues to the variation of environmental conditions throughout earth's history. This idea can be applied readily to paleoceanographic changes through time since the marine fauna and flora (and less directly, the terrestrial fauna and flora) all have certain environmental parameter tolerance ranges. If these environmental parameters vary beyond the adaptive capabilities of the organisms and species, extinction may occur.

Biologic extinctions may be categorized into two general types: 1.) mass extinction events, and 2.) normal or background extinction events. To be considered a mass extinction event, the extinctions should occur over a relatively short period of time (e.g., 1-5 million years), affect many different taxa, and the magnitude of the event should affect the taxa greatly (e.g., more than 50% of species go extinct). Without these characteristics, normal faunal turnover is considered background or normal extinction.

As described earlier, the terminal Eocene extinction event is included in the marine fossil record at both the familial and generic taxonomic levels. The data presented by Raup and Sepkoski (1982, 1986) may not represent a true mass extinction event, however, when the timing of the event is considered. The data represent resolution only to stage level, with the mean stage duration given as 7.4 million years (Raup and Sepkoski, 1982). This means the timing aspect for the possible mass extinction may be too generalized when considering higher taxonomic levels, and interpretation of the cause and effect of paleoceanographic changes may be blurred when based on data such as these. Discussion of several taxa of marine invertebrates (in addition to the echinoids) and their extinction patterns near the end of the Eocene are described in the following paragraphs.

Foraminifera have been studied in detail and used extensively for biostratigraphy of marine sediments. They are valuable (particularly the planktonic taxa) because of their wide distribution in ocean waters and their strong representation in many marine deposits. The resolution of foraminiferal

biozones based on various species can be defined within several hundred thousand years, so the timing aspect of their extinction patterns is excellent. Further, because this group contains many extant taxa, distribution patterns within the water mass and geographic distribution can be studied via living taxa to aid environmental interpretations for related fossil taxa. Specifically, geochemical analysis of their $CaCO_3$ tests yields isotope data that are valuable for these ecological changes in the water mass to be recorded and interpreted.

Keller (1983) examined deep sea sediments from several DSDP sites in the Indian, southern Pacific, and southern Atlantic Oceans (sites 363, 292, 219, and 277). She made several interpretations of the water mass and climatic changes based on faunal turnover patterns of planktonic forams in the sediments. She noted four major changes in water mass stratification between the middle Eocene and late Oligocene based on global foraminifera faunal turnover. These changes in foraminifera species groups (where surface=warm, intermediate=cool, and deep=cold) suggest confirmation of the development of the psychrosphere (Benson, 1975) as the driving force for faunal turnover in the late Eocene. Furthermore, she noted that the global faunal turnover (extinctions) corresponds to major climatic change as well as a change in the global sea level curve. However, it is stressed that the foraminifera faunal turnover at this time supports the model of catastrophic extinctions at the Eocene-Oligocene boundary, as previously proposed by other research. One important theme of Keller (1983) is the support of temperature change (cooling) as the driving force for the faunal turnover.

Keller (1986) also examined planktonic foraminifera in detail, with emphasis on the extinction events with regard to their timing, magnitude, and relationship to specific driving mechanisms. This study examined 37 late Eocene to Oligocene sections, most of which are DSDP sites from the Pacific, Indian, and Atlantic -Caribbean Oceans. Planktonic foraminifera datum events were established for dominant species and it was noted that 17 of 26 datum events fall between the Eocene-Oligocene boundary and 38.4 Ma, thereby reflecting rapid species turnover during a time of accelerated stepwise extinctions.

Keller (1986) demonstrated that close examination of the foraminifera species record shows that successive extinctions occur abruptly over short stratigraphic intervals, creating a stepwise extinction effect. This is counter to the traditional view of a single, catastrophic mass extinction at the Eocene-Oligocene boundary. The number of species extinct at each stepwise extinction event generally is less than 15% of the species population and therefore would not represent a mass extinction. She points out, however, that the sum total of the late Eocene stepwise extinctions over the 3.4 million year interval (40.0-36.6 Ma) results in a nearly complete faunal turnover, with only 20% of the species surviving into the Oligocene.

The Eocene-0ligocene extinction event in low to middle latitudes primarily represents a redistribution in the abundance of dominant species. Frequency changes in dominant species are less extensive at the boundary than at earlier stepwise extinction events. Temperature affinities of the dominant species indicate a gradual replacement of warm water species by cooler water species,

but Keller (1986) acknowledged that the extinctions may be the result of multiple causes. However, the proximal cause appears to be temperature-related (cooling) even if the ultimate cause is unclear. This idea is reinforced by other foraminiferal workers such as Berggren (1977), Corliss (1979), Keigwin (1980), Corliss et al. (1984), Keigwin and Corliss (1986), and Boersma et al. (1987), for both the gradual stepwise extinction pattern of foraminifera as well as the proposed causative force (temperature decrease).

Deep-sea benthic ostracodes have been used to compare faunal changes with proposed paleoceanographic events for the Tertiary, and two events are of interest here. First, Benson (1975) used ostracode faunal shifts in deep-sea sediments to interpret the development of the psychrosphere at approximately 40 Ma. Although limited extinction of ostracode taxa occurred, it was significantly earlier than the Eocene-Oligocene boundary event and Benson (1975) therefore called it the "40-million year event." Benson et al. (1984) examined in greater detail the global distribution and patterns of change for benthic ostracodes from 156 DSDP sites (with specimens identified to the generic level). They found a decrease in global generic diversity and abundance in the ostracodes at the Eocene-Oligocene boundary (36 Ma), but it apparently was not as significant as the turnover at 40 Ma. Again, this shows an example of the potential error in assuming a mass extinction event at the end of the Eocene if the timing of the event cannot be carefully determined. Here, the ostracode event at 40 Ma likely would be included as part of the late Eocene extinction along with the true end-Eocene event (of lower magnitude) at 36 Ma.

Radiolarians also show faunal turnover at the end of the Eocene, but it is only of minor significance when compared to global diversity. Correlation of the radiolarian extinction pattern with impact horizons (microtektite layers) in sections from Barbados (Sanfilippo et al., 1985) and DSDP cores from the Gulf of Mexico and Caribbean (Glass and Zwart, 1977) have been documented. However, this faunal turnover may simply reflect part of a significant environmental change in the oceans as is interpreted from the foraminifera and ostracodes patterns (Keller, 1986).

Molluscs also have been studied in some detail regarding extinction and relationship to causal factors such as shelf area and temperature changes, and impact events at the end of the Eocene (Hansen, 1987). Although Hansen's study is restricted to Gulf Coast faunal patterns rather than global patterns, the pattern's relationship to global ciimatic or paleoceanographic events may be interpreted from these data. Hansen (1987) compared molluscan extinction and diversification patterns from several formations of middle Eocene to Oligocene age. The taxa were identified to species level, but stratigraphic resolution was somewhat coarse since it was limited to appearance of taxa by formation. He found both gastropods and bivalves exhibited similar trends in diversity, with a high in the late middle Eocene, interpreted to likely be a function of increased temperature and shelf area at this time.

The temperature drop present at the middle Eocene-late Eocene boundary and the Eocene-Oligocene boundary are strongly reflected in the molluscan diversity data. Hansen noted a molluscan species extinction of 86%

and diversity drop of 29% at the middle Eocene-late Eocene boundary and a 97% extinction of the already depleted fauna at the Eocene-Oligocene boundary. He also compared species abundance of warm water genera versus cool water genera and he found the warm water genera suffer a higher specific extinction rate than cooler water genera across the Eocene-Oligocene boundary. This corresponds to similar results for planktonic foraminifera as reported by Keller (1983). A comparison of species-richness values for transgressive stratigraphic units versus regressive stratigraphic units shows no significant correlation between extinction of molluscs and shelf area for the middle Eocene through Oligocene units. Therefore, Hansen (1987) concluded that: 1.) the molluscan extinctions are stepwise in character through the late Eocene to early Oligocene (not catastrophic at the Eocene-Oligocene boundary) and, 2.) temperature drops appear to be the primary cause of extinction because of the selective loss of warm water taxa.

Echinoid extinction and diversity patterns have been studied in relationship to temperature changes and sea level changes for the Tertiary, with particular emphasis on the terminal Eocene extinction event. McKinney and Oyen (1989) examined the statistical correlation of global and Coastal Plain echinoid diversity with two potential causative forces for extinction (i.e., sea level and temperature change) because these factors can be quantified from the fossil record. The resolution for the diversity data is limited to the stage level for Coastal Plain echinoid species and is even coarser for global species diversity

(epoch level), so this study resembles the resolution level used for the molluscs by Hansen (1987).

A distinct pattern appears for the echinoid diversity at the Eocene-Oligocene boundary (for both global and Coastal Plain species diversity as reported by McKinney and Oyen, 1989), with a dramatic drop in diversity and increase in extinction. Comparison of the diversity data with sea level and temperature showed the affinity to temperature change to be stronger in a qualitative sense. This relationship was supported further after statistical correlation of these data reinforced the qualitative comparison quantitatively and they proposed that temperature may account for nearly 90% of the diversity variation. It must be noted that the data used by McKinney and Oyen (1989) are quite limited in stratigraphic and chronological resolution as compared with much of the foraminifera data, but the general interpretations of a significant environmental perturbance at the end of the Eocene agrees with other works described earlier. The limited resolution does not allow for further refinement of the timing of the paleoceanographic changes in detail, and therefore may or may not support the idea of a significant mass extinction event at the end of the Eocene. They also suggested that temperature may be only one of several forces causing extinction but it appeared to be a proximal cause even if not the ultimate cause of echinoid extinction.

Data generated for this dissertation do not show a significant increase in the resolution of stratigraphic information or chronological information that would allow greater understanding of the Eocene-Oligocene boundary event. My data

tend to follow a similar diversity trend from the Eocene into the Oligocene (although slightly different in magnitude), with no significant diversity decrease from the middle Eocene into the late Eocene (as shown in some of the other taxonomic groups). Thus, at the resolution available for my data, it seems more probable that the environmental conditions were favorable throughout the late Eocene in this geographic region, but did indeed change significantly by the end of the Eocene.

Chapter Summary

The Cenozoic echinoderm record in Florida is relatively good, but certain aspects of collecting specimens (to aid in reconstructing the stratigraphic distribution and taxonomic diversity) can be greatly improved. One of the more valuable techniques which has allowed my research to increase the known diversity values for the Middle Eocene through the Pleistocene is close examination of the microscopic components of the sedimentary rocks sampled, both while in the field or after bulk-sampling and returning to the lab. These sieved samples have produced numerous echinoderm ossicles and other fragments that have proven to belong to taxa not recognized prior to my work and, in some cases, taxa that represent new species. A second method used in my research was the production of silicone peels of moldic rock units. Several taxa are known only from molds (either internal or external), and the peels made from them have reproduced the morphology in great enough detail to allow lower-level taxonomic identifications.

As a result of closer examination of strata and their sedimentary rock during fieldwork, the study of a variety of museum and research echinoderm collections, and a thorough review of the published literature on Florida paleontology and stratigraphy, I have significantly improved what is known about the diversity and biostratigraphy of fossil echinoderms in the state. The resulting overall pattern of echinoid diversity from the Eocene through the Pleistocene is consistent with the previously described pattern throughout this time interval, except during the Miocene. My new stratigraphic and taxonomic records of echinoids show an increase in diversity for each epoch, but the pattern of change from the Paleogene to the Neogene now reflects a different trend. Previously published Florida echinoid data (McKinney and Oyen, 1989; McKinney et al., 1992) show a diversity decrease from the Eocene to the Oligocene, and continuing into the Miocene. This contrasts with the worldwide echinoid diversity pattern, which shows a higher diversity in the Miocene than in the Oligocene. The revised Cenozoic echinoid diversity data from Florida show a trend that more closely follows (using proportional diversity of the raw number of species per epoch) the global pattern for echinoids. However, when diversity values are normalized by epoch duration, the Florida data show a much lower proportional diversity for the Miocene as compared with the global pattern.

Florida is not the only place with this low Miocene normalized diversity, as a similar pattern also is present in Jamaican echinoids (Donovan, in press), which may represent a regional effect in the Caribbean and Gulf of Mexico. One of the reasons for the improved alignment of local (i.e., Florida) and global

patterns is the significant number of additional taxa recognized from the Miocene as a result of this study. The Cenozoic echinoids in Florida still do not directly mimic the global pattern, but as work continues the local, regional, and global patterns may begin to match more closely.

The Florida echinoderm diversity pattern and fossil record is influenced by a number of biases, not unlike the fossil record of other taxa. These biases include factors such as variations in outcrop exposure among the Cenozoic formations, revisions of stratigraphic boundaries and names, differential preservation potential in carbonate versus siliciclastic environments, unequal temporal ranges of epochs, revisions of taxonomy at the generic and specific levels, and the normal tendency for people to collect unbroken and larger fossils preferentially over small, fragmented, or disarticulated skeletal remains. Any of these biases, whether independent or additive, affects the ability of paleontologists to assemble a complete picture of the echinoderm record from Florida or any other geographic region in the world. This dissertation is only the first attempt to synthesize a complete Cenozoic echinoderm database for Florida, and represents a building block which I use to augment the fossil echinoderm record in the state and move forward in the research on the echinoderms.

CHAPTER 5
ALLOMETRIC HETEROCHRONY IN MELLITID ECHINOIDS: A CASE STUDY FROM FLORIDA

Preface to the Biometric Analysis

Original Research Objectives

The original objective of my research was to carefully study the growth of modern echinoids with the goal of determining if growth in echinoids is such that skeletal calcite accurately records the individual's ontogenetic age. This would permit standardization by common age in evolutionary series of fossil lineages so that heterochronic patterns and mechanisms could be assessed. However, the growth analysis was unsuccessful largely because of mass mortality of the modern test population of echinoids before a full year of growth was completed. Another unexpected result was the lack of visible and traceable growth lines in the skeletal plates of those individuals that survived for the necessary full-year time period. Thus, quantitative analysis of the biometric data gathered from selected echinoids of Florida proved to be the most problematic for me to complete in the method anticipated in the planning stages of the dissertation.

Growth in echinoids occurs by peripheral accretion of individual test plates as well as addition of new plates (Swan, 1966; Raup, 1968; Smith, 1984).

Unfortunately, little is known concerning the growth rate of echinoids during ontogeny. Groups such as molluscs (Jones, 1988) and plants (Guerrant, 1988) allow determination of their ontogenetic age with fine resolution. Thus, we may assume reasonable confidence for interpretation of the mechanism responsible for morphological change in the taxa. For many other taxa (including the echinoids) a technique for determining an organism's ontogenetic age is yet unproven.

Growth Study Procedure

Determination of growth line regularity was attempted by “tagging” living echinoids via injection with tetracycline hydrochloride. The echinoid species Mellita quinquiesperforata (irregular echinoid) is found living along the Gulf of Mexico coast of Florida in the Cedar Key and Seahorse Key area. Following the tetracycline tagging technique of Kobayashi and Taki (1969), a large number of individuals of the species were collected and tagged. I followed the optimal dosage of the tetracycline (determined by Kobayashi and Taki) as 1-2 mg per 10 g live urchin weight, with the tetracycline mixed with seawater in a ratio of 1 mg per 0.1 ml of seawater, and the solution was injected into the urchin through the peristome.

After the injection of tetracycline, the echinoids were placed in "fenced" enclosure areas near Seahorse Key that allowed continued exposure to natural conditions, yet also allowed the tagged individuals to be collected later (while minimizing specimen dispersal). The enclosures consisted of hardware cloth

(~12 mm mesh "chicken wire") fence material embedded 10-20 cm into the substrate to prevent escape of the sand dollars.

The tetracycline is incorporated into the calcite test as it accretes (at least ideally this is true) and results in distinctly colored lines in the test when the test plates are viewed under reflected ultraviolet light. Therefore, the injection serves as a time reference marker in the test's plates and potentially can be used to interpret periodicity of growth line development. A number of the previously tagged individuals then were collected at three month intervals, measured, and sacrificed to determine any seasonal growth variation and to document the presence of any new growth lines. Also, environmental conditions such as salinity and temperature were recorded when collecting the specimens.

Two problems occurred during this experimental procedure that required me to alter the dominant focus of my research from that of heterochrony analysis to biostratigraphy and diversity pattern analysis. The first problem encountered was the mass mortality of the study population of echinoids. As part of the procedure for growth study of the population, I traveled to Seahorse Key at intervals of approximately three to four weeks to gather data of general test length and width biometrics, as well as measurements of salinity and water temperature conditions. At approximately eight months into the 12-month growth study I discovered that nearly all echinoids in the enclosures had died. A significant amount of algae as well as other organic and non-organic matter had become entangled in the echinoid enclosure fencing material through some event such as storm wave activity. These attached materials thereby acted as

baffles preventing water circulation through the enclosures, and initiating the settlement of a thick (4-8 cm) layer of clay- and silt-sized sediment out of suspension. Therefore, I interpret the mortality of the echinoids to be the result of "death by suffocation," since these organisms generally require coarser substrates with modest water movement to allow efficient respiration of dissolved oxygen via their tube feet.

The second problem involved analyzing growth lines in the echinoid test plates. Since the mass mortality occurred before a full year had passed, the ability to judge periodicity of growth line emplacement became undeterminable. Growth lines in echinoid test plates were reported as early as the mid-1800s in the literature, and the possibility these lines are cyclic in formation is both supported (Raup, 1968; Jensen, 1969; Weber, 1969; Pearse and Pearse, 1975; Smith, 1984) and disputed (Heatfield, 1971; Ebert, 1986). Supporters of cyclic growth line development generally attributed their formation to seasonal cycles in growth rate due to factors such as temperature, reproductive state, food availability, or storms. Studies such as Ebert (1986) and Weber (1969) were concerned with growth lines in spines rather than test plates. Ebert believed these rings were due to disturbance effects as well as growth and thus are not cyclic in nature. Weber found rings established even when trauma was not a factor. Neither worker was able to quantify the period of time present between ring establishment. Therefore, it was impossible to distinguish the chronological significance of any lines in the plates. Furthermore, when the plates of the "early" mortality echinoids were examined for tetracycline banding, no

consistency in the age marker bands could be established. That is, I could see fluorescence of the tetracycline under ultraviolet light, but it was distributed sporadically rather than consistently through various plate sections in the test.

The effort was not a complete failure, however, as I have incorporated the biometrics of the Seahorse Key echinoids into the database of biometrics from the fossil specimens. Mellita quinquiesperforata is reported herein as part of the fossil record of Florida, but the recovered fossils are poorly preserved (usually highly fragmented) and therefore did not allow measurements to be made on those specimens. As a result, I was able to use the biometric data from these specimens as part of the allometric heterochrony analysis of the mellitids in Florida.

Introduction and Heterochrony Overview

Heterochrony, the change in timing of an organism's development during ontogeny, is not a new idea in the field of evolutionary study. Ernst Haeckel (1875) provided the term to delineate anomalies in evolution as described in his biogenetic law regarding single organisms (within a species). Our present concept of Haeckel's idea was indelibly altered by de Beer (1930), who generalized it to become the change in developmental timing of a feature relative to the same feature in an ancestor (see Gould, 1988).

Perhaps it is true that the specific definition of heterochrony accepted and applied today is not what was intended by the original presentation of Haeckel. Nonetheless, heterochrony can give useful insight to ecological changes that

influence these developmental changes. As McNamara (1982) noted, these changes may result in normal phenotypic variation or, if of adaptive significance, selection for the morphologic variant leading to speciation.

An increasing number of publications regarding heterochrony in the evolution of various taxonomic groups reflects the increasing awareness and interest in this field in recent years. Two publications in particular, Gould (1977) and Alberch et al. (1979), have elucidated the important tripartite relationship of time (age), size, and shape to heterochrony. Gould's approach is more qualitative while Alberch et al. emphasize a quantitative analysis of the heterochronic processes and their identification. McNamara (1986) provided a concise yet valuable explanation of the terminology and diagnostic characteristics for the heterochronic processes found in current literature (Figure 5-1). More recently, McKinney and McNamara (1991) have elaborated on the mechanisms, modes, and effects of the evolutionary changes resulting from heterochrony as related to wide variety of living organisms.

Allometry has been stressed in previous heterochronic studies, typically through bivariate morphometric analysis of ontogenetic growth trajectories. Ontogenetic age data for fossils often is not obtained or is disregarded and heterochrony is then described using only two of the three characters, size and shape change. It is not possible to characterize the change in developmental timing unless the ontogenetic age is known at the various developmental stages for the individual. When size is equated with age, "allometric" heterochrony rather than true heterochrony is defined (McKinney, 1988; p. 24). That is,

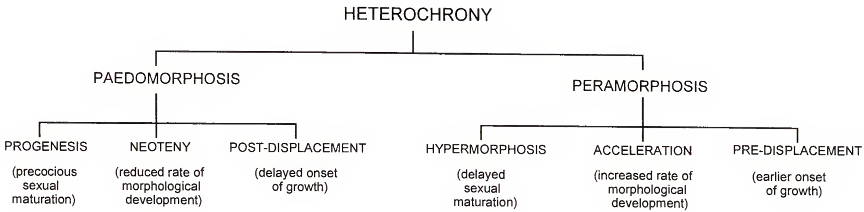


Figure 5-1. The hierarchy of heterochrony. (From McNamara, 1986)

allometric heterochrony is a pattern interpreted via analyses involving shape and size, rather than ontogenetic age. Organisms that have continuous growth throughout ontogeny should reasonably be expected to reflect age via body size. It must be noted that problems arise, however, in cases where body size is not a reliable indicator of ontogenetic age, and thereby invalidate the size-based approach to heterochronic analysis (see McKinney, 1988; McKinney and McNamara, 1991 for further explanations). An example of an invertebrate group whose body size does not necessarily reflect a direct correlation with age are bivalves, which may have two individuals of the same size varying in ontogenetic age by 50-100 years (Jones, 1988). Recently, Jones and Gould (1999) expanded upon the implications and explained how the assumption of size as an indicator of age has produced errors in characterizations of heterochrony patterns for Gryphaea. Thus, I recognize the limitations inherent in size-based interpretations and accordingly consider my results to be "allometric" heterochrony interpretations in contrast to those based on known age (i.e., the "true" heterochrony styles).

The purpose of the analysis described herein is to illustrate the styles of allometric heterochrony present in select species of sand dollars in the family Mellitidae from the Cenozoic in the southeastern U.S.A. The data included within this chapter are the only data for this dissertation that include fossils not necessarily present in strata from the state of Florida (those few selected fossils were originally collected from South Carolina localities). The data generated from the species of Encope and Mellita are derived primarily from fossils. Mellita

quinquiesperforata is the only species represented by individuals sampled from a modern population (rather than a fossil population) located surrounding Seahorse Key, Florida, in the Gulf of Mexico. Bivariate regression analysis was completed on morphologic characters to generate allometric growth trajectories used for the heterochrony analysis of these mellitids. Finally, a brief comparison with paleoecological and modern ecological conditions during the species' evolution is provided to help identify the potential environmental selective impetus in the evolutionary history of the fossil mellitids.

Materials and Methods

Materials Examined

The primary goal of this project is to identify the styles of evolution present in available species of fossil mellitids from the southeastern Coastal Plain, and in particular, Cenozoic fossils from Florida. The species under examination are those that are reasonably well preserved, thereby allowing easy specimen preparation and access to the variety of morphological characteristics for biometric purposes. Second, the species were available for study either via personal collection through fieldwork or through examination in museum collections. Up to nine species (depending on taxonomic validity of species designations) of mellitids are included in my database of biometric measurements and analyses.

The species examined here include the fossils Encope tamiamiensis Mansfield, 1932 (Tamiami Formation, Pliocene, Florida), Encope michelini

Agassiz, 1841 (uncertain unit ?, Pleistocene ?, South Carolina; also found in the Anastasia Formation, Pleistocene, Florida), and Mellita aclinensis Kier, 1963 (Tamiami Formation, Pliocene, Florida). The fourth taxon is represented by individuals of Mellita quinquiesperforata (Leske, 1778) that were sampled from a modern population near Seahorse Key, Florida, in the Gulf of Mexico (note that this species also occurs as a fossil in the Satilla Formation of Florida). Personal fieldwork provided all specimens of M. quinquiesperforata while all specimens of M. aclinensis and E. tamiamiensis are part of the Invertebrate Paleontology Collection at the Florida Museum of Natural History in Gainesville, Florida. Finally, all measured samples of E. michelini were obtained from the U.S. National Museum in Washington, D.C.

Data Acquisition Methods

Biometric data were gathered using Fowler Ultra-Cal II electronic calipers, accurate to 0.01 mm. The calipers were connected to a Dell NL20 laptop computer, which allowed the each measurement's datum to be sent and compiled directly in a spreadsheet program running on the computer. Following collection, data were then exported to statistical analysis programs to complete the data analysis. Univariate statistics were calculated using a Macintosh computer and the commercial statistics computer program StatView (both versions II and 5.01 were used). All biometric measurements were subjected to base 10 logarithmic transformation before regression analysis. Calculation of a Z-statistic, as a test for determining significant differences in slope means

between species pairs, and conversion of least-squares regression output to reduced major axis regression (RMA), were completed using a PC computer and computer programs I wrote via the BASIC programming language to produce such conversions.

Biometric measurements were produced using 372 individuals from several echinoid species within the family Mellitidae. The species that were more abundant in the collections allowed more than 100 specimens to be measured. Several species are relatively rare in the field as well as in fossil collections, and therefore are represented by as few as 7 specimens in this data set. The number of specimens measured for each species in this study ranges from 7-131. Up to 64 separate measurements were taken on each echinoid specimen, depending on the state of preservation of the individual fossil. All trait measurements were taken on all specimens, except in those circumstances where one or more species did not have the same morphologic feature present as part of its skeleton. For example, ambulacral lunules are not present in species of Encope, therefore the trait has no data available for those specimens. Incomplete specimens, or those fossils with encrusted or cemented matrix that was unable to be removed, had fewer biometric data compiled from them. Morphologic landmarks were established to allow similar data files to be established for each species, and include common measurements such as test length (TL), test width (TW), peristome length, width, and position (PSL, PSW, PSP), among numerous other traits discussed below.

Biometric Traits Evaluated

Biometric data were gathered from morphologic traits present on all species of mellitids examined in this study. Many of these traits commonly are used in biometric analyses of modern and fossil echinoids, while several traits and associated variables were established as unique to this project. Morphologic landmarks were defined to allow similar data files to be established for each species. Trait types and locations include most of those described by Harold and Telford (1990), as well as additional variables chosen as unique for this study. Figure 5-2 shows representative locations of biometric measurements associated with the species of mellitids while Table 5-1 lists the trait abbreviation or acronym and the description of the trait location on the echinoid test.

All numbering associated with traits (using I-V and 1-5) follows Lovén's (1892) system, in which ambulacra use Roman numerals and interambulacra use Arabic numerals. Most traits identified and measured are in multiples of five due to their association with the ambulacra and interambulacra on the echinoids. Therefore, those trait measurements are designated by having the affiliated Arabic and Roman numerals (in parentheses after the trait acronym) using the Lovén system as noted above. Biometric traits that are not associated with the ambulacra and interambulacra skeletal regions lack such numerals. A total of 24 independent and unique morphologic traits were evaluated, that resulted in a sum total of 64 traits when the five-fold multiples are considered as individual traits.

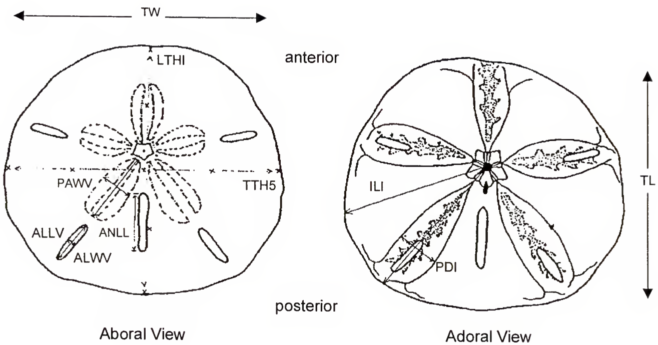


Figure 5-2. Representative sketch showing locations of biometric measurements on mellitid echinoids. The illustration shown here is of Mellita quinquiesperforata, but it is representative of the species included in the biometric analysis. Note that not all species within the family will have all of the traits exhibited on this illustration (e.g., species of Encope will not have ambulacral lunules like species of Mellita).

Table 5-1. Biometric trait descriptions.

TRAIT	TRAIT DESCRIPTION
TL	Test length
TW	Test width (at midpoint of TL)
PSL	Peristome length
PSW	Peristome width
PSP	Peristome position (from anterior test margin to anterior peristome margin)
PPL	Periproct length
PPW	Periproct width (at midpoint of PPL)
PPP	Periproct position (from anterior periproct margin to anterior peristome margin)
POSAP	Position of apical system (from anterior test margin to center of apical system)
ANLL	Anal lunule length (interior lunule length, aboral side)
ANLW	Anal lunule width (interior lunule width, aboral side, at midpoint of lunule length)
ANLP	Anal lunule position (distance from anterior lunule margin to apical system center)
PD(I-V)	Pressure drainage channel span (max. width, adoral surface)
TWMX	Test width maximum
LTH(1-5)	Longitudinal test height (at 5 equidistant points starting at anterior test margin)
TTH(1-5)	Transverse test height (at 5 equidistant points starting at left test margin)
PAL(I-V)	Petaloid ambulacrum length (aboral ambulacrum length, from apical system margin to maximum pore-pair position)
PAW(I-V)	Petaloid ambulacrum width (aboral ambulacrum width, at midpoint of ambulacrum length, from outer pore-pair to outer pore-pair)
THMX	Test height maximum
AL(I-V)	Ambulacrum length (adoral surface, peristome margin to test margin)
IL(1-5)	Interambulacrum length (adoral surface, peristome margin to test margin)
ALL(I-V)	Ambulacral lunule length (aboral surface, interior length)
ALW(I-V)	Ambulacral lunule width (aboral surface, interior width at midpoint of length))
ALP(I-V)	Ambulacrum lunule position (from center of apical system to adapical lunule margin)

Data Analysis Methods

Summary statistics were generated for all biometric traits to use as reference for comparison with original species descriptions and morphology observed in populations that were sampled. Bivariate regression analysis was applied to the data to generate growth trajectories for the biological characters used as variables. Reduced major axis (RMA) regressions were produced and used here rather than least-squares regressions because the RMA method is more appropriately applied to biological growth systems where a truly independent variable may be difficult to discern (see Davis, 1986 for a review of details regarding variable assumptions in this method). Since all components (i.e., morphologic traits) of this analysis involve allometric changes during growth of the echinoids, a true, independent variable may not exist and therefore the RMA method is a better regression option. Recognizing this factor, test length (TL) was chosen as the most likely representative or proxy of body size, and therefore is designated as the independent (x-axis) variable in all calculations. This regression method reveals allometric changes that occur as part of the skeletal growth of the echinoid species, which in turn then is used to interpret allometric heterochrony styles present in the taxa of interest to this study.

McKinney (1986) established models for allometric heterochrony interpretations based on regression data for biometrics. The six styles of heterochrony may be distinguished based on the slopes and y-intercepts for the equation of generated regression lines, as well as species body size. An illustration of this model's format is provided in Figure 5-3. Explanations of all

assumptions and limitations in using this diagnostic model are provided in McKinney (1986, 1988) and McKinney and McNamara (1991). Regression data from the selected Neogene mellitids then were compared with the model for interpreting heterochrony patterns present in the taxa. Approximately 3500 bivariate regression plots were generated during my analysis and examples of two such plots are provided in Figure 5-4. It is possible to visually distinguish the heterochrony pattern from plots such as these, but statistical tests were used to confirm any interpretations. Due to the large amount of statistical output (both graphic and tabular) generated during the analysis, I only present a simple example of the output here and summarize the rest of the information in tables in the results section.

In this paper, RMA slopes and y-intercepts are compared at the .05 level of significance using the Z-test statistic, and all regressions must have r^2=0.80 or greater for inclusion in the comparisons. Regressions for all data included here use log-transformed biometric data. Finally, where interpretations of progenesis or hypermorphosis are provided, the body size (TL) critical value is determined using the TL value at two standard deviations above the mean for the species sample (Table 5-2).

Results

The general results of the heterochronic relationships between the species pairs are shown in Table 5-3. The method used to determine the evolution style follows that used by McKinney (1988). A clear dominance of peramorphosis

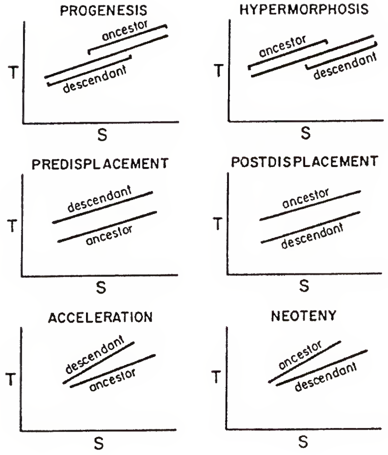


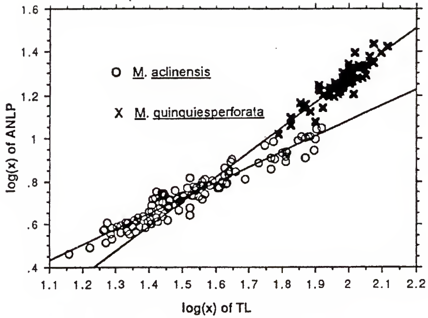
Figure 5-3. "Allometric" heterochrony, as classified by the ontogenetic plots of related species. Axis S = body size (test length for the echinoids), and axis T = trait measurement. S and T do not require variables to be log-transformed for the model to work, but the data in this dissertation are log-transformed for the analysis. Sketches illustrate hypothetical body size (light circle), and trait size (e.g., test width, ambulacrum length, etc.). (From McKinney, 1988)

Figure 5-4. Examples of reduced major axis (RMA) regression plots for the species pair M. aclinensis and M. quinquiesperforata. Data is log-transformed and the independent variable (proxy for size) is the test length (TL).

A) Dependent variable is anal lunule position (ANLP) and, based on a difference in RMA slopes, the heterochrony style illustrated is acceleration (slope of descendant M. quinquiesperforata is less than ancestor; Z=-8.58, n=119 for M. aclinensis and n=71 for M. quinquiesperforata) .

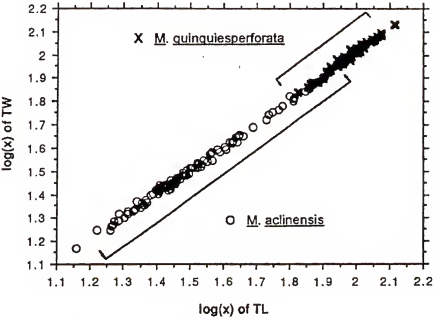
B) Dependent variable is test width (TW), and since both the slope and y-intercept are not statistically different but the mean TL value is greater for the descendant, the heterochrony style illustrated is hypermorphosis (Z_{slope}=-0.31, $Z_{y\text{-}intercept}$=0.90, n=117 for M. aclinensis and n=64 for M. quinquiesperforata).

A)



y = 0.74x + 0.98, r^2 = 0.921 M. aclinensis
y = 1.25x + 0.40, r^2 = 0.821 M. quinquiesperforata

B)



y = 0.99x + 0.006, r^2 = 0.997 M. aclinensis
y = 1.00x - 0.014, r^2 = 0.978 M. quinquiesperforata

Table 5-2. Echinoid body size (TL) calculations for mellitid species included in heterochrony analysis. The following represents the summary data for the echinoids regarding length, maximum length, and length at 2 standard deviations above the mean test length (both for corrected, where n<10, and uncorrected factors, where n 10). Asterisks indicate a modified file that includes closely related species that may be conspecific, rather than truly unique. Acronyms included in parenthesis beneath species names are used as code for location within biometrics data file of Appendix.

Species	N	mean (μ) TL (mm)	Population std. dev. (σ) (uncorrected)	Population std. dev. (σ) (corrected)	Test Length (mm) sample maximum (observed)	population max. estimate ($\mu + 2\sigma$)
M. aclinensis (ACL)	124	37.29	17.20	NA	83.08	71.70
M. caroliniana (ACS)	18	55.54	21.86	NA	105.96	99.26
M. aclinen./carol.* (ACL+ACS)	141	39.48	18.80	NA	105.96	77.07
M. quinquiesperforata (QUI)	71	95.67	13.39	NA	130.27	122.45
M. isometra (QUS)	9	108.79	24.43	29.08	151.30	166.96
M. quinquie./isometra * (QUI+QUS)	80	97.14	15.39	NA	151.30	127.92
E. tamiamiensis (TAM)	121	47.98	21.08	NA	109.52	90.14
E. macrophora (MAS)	7	49.80	27.57	23.31	89.16	96.41
E. michelini (EMS)	9	81.83	12.62	11.32	97.02	104.48

exists in the ancestor - descendant pairs, with paedomorphosis only accounting for less than 20% of the traits involved in the analyses. An unequal balance exists among the three styles of peramorphosis as well, with acceleration distinctly more common in the M. aclinensis-M. quinquiesperforata and E. tamiamiensis-M. quinquiesperforata pairs. Hypermorphosis is most common among the morphologic traits of the E. tamiamiensis-E. michelini relationship, and it is secondary in prevalence to acceleration in the other species pairs illustrated here. The other style of peramorphosis, pre-displacement, is relatively rare or absent for each of the three species pairs. A point that may be made regarding the heterochrony styles is the dissociated rather than global nature within the individuals of a given species. This is not unique to the mellitids, or echinoids as a group, and should be expected when a fixed number of morphologic traits are varying during allometric growth of the organism (i.e., a "closed" system of sorts).

An illustration of how the most common varieties of peramorphosis can be readily determined graphically is shown in Figure 5-4 for two of the morphologic traits analyzed in the M. aclinensis - M. quinquiesperforata relationship. This was done for all morphologic traits examined in each species pair (though not shown for all traits), and then related to the graphic model of McKinney (1986). It is a relatively simple procedure and model to use and visually perceive when the slopes of various regression lines are distinctly different, as well as in the cases where the slopes and y-intercepts of regression lines are not different, as shown in the two cases in Figure 5-4. All equations of the regression lines were tested

for statistical significance (at the 0.05 confidence level) in difference in slope and y-intercept for all traits (using the Z-test), no matter how easy or difficult to perceive by visual methods alone. It must be noted that for this study, no cladistic phylogeny was completed, and therefore the ancestor-descendant species pairs must be viewed with caution until such data are available.

The most interesting aspect of these heterochrony patterns is derived not from the simple documentation of the patterns, but rather by relating the patterns to potential "causal" forces or environments that allow selection for traits to occur. McKinney (1986) demonstrated a non-random relationship between the energy of environment in which certain fossil echinoid taxa were living and the heterochrony patterns of evolution among closely related taxa. For the echinoids he examined (none of which were mellitids), he found a high proportion of species-pairs reflecting the presence of paedomorphosis (particularly neoteny) when evolution occurred in a change from unstable to more stable ecologic conditions. The opposite held true in which patterns of peramorphosis reflected a change from stable to more unstable environments.

The evolutionary trends of the mellitids examined in this study seem to support the model McKinney proposed. When the evolution of the species pair M. aclinensis - M. quinquiesperforata is considered, I have shown a predominance of peramorphosis styles of acceleration and hypermorphosis for these species. The fossils of M. aclinensis are found in great abundance in portions of the Tamiami Formation (Pliocene) at some of the classic Pliocene shell pits of central and southern Florida. The paleoecology of the beds

containing these echinoids at a locality such as the Lomax-King Pit (now inactive) in Charlotte County can be interpreted as representing intermediate to shallow water depths and with moderate water energy. The modern environment where the extant species of M. quinquiesperforata was collected, represents an intertidal to very shallow subtidal water depth, having a moderate- to high-water energy (particularly during storm events). The fossil representatives of M. quinquiesperforata also have been collected from high-energy nearshore sand deposits of the Satilla Formation. Although the two species do not represent extreme differences in water energy and depth, based on my paleoecologic interpretation it is likely that modern environment is a higher energy setting on average than that which existed at the time M. aclinensis was inhabiting the paleo-coastline of Florida.

Although not all species measured are represented in the examples of this chapter, the general pattern is present throughout the species of the family Mellitidae. As my summary of the heterochrony analysis, I interpret that the mellitid echinoids examined as part of this study tend to follow the general echinoid model and pattern of evolution shown by McKinney (1986) and McNamara (1982). The mellitids produce a general peramorphocline trend in the southeastern Coastal Plain, shifting from slightly deeper and more moderate energy water conditions, to shallower depths and higher energy. During this evolutionary transition, the mellitids exhibit predominant patterns of peramorphosis, with acceleration and hypermorphosis styles most common.

Table 5-3. Percent distribution of allometric heterochrony styles for selected ancestor-descendent species pairs as interpreted from RMA regression analysis. Note predominance of peramorphic styles for each species pair. Regression lines must be at $r^2 = 0.80$ or greater for inclusion in final analysis. Thus, less than 60% of total traits measured are included in these calculated values.

PAEDOMORPHOSIS		PERAMORPHOSIS	
Mellita aclinensis vs *Mellita quinquiesperforata*			
Neoteny		*Acceleration*	
1 trait	2.7 % of total	18 traits	48.6 % of total
Progenesis		*Hypermorphosis*	
0 traits	0.0 % of total	11 traits	29.7 % of total
Post-Displacement		*Pre-Displacement*	
6 traits	16.2 % of total	1 trait	2.7 % of total
18.9 % of total traits		81.0 % of total traits	
Encope tamiamiensis vs *Encope michelini*			
Neoteny		*Acceleration*	
3 traits	9.7 % of total	10 traits	32.3 % of total
Progenesis		*Hypermorphosis*	
0 traits	0.0 % of total	18 traits	58.1 % of total
Post-Displacement		*Pre-Displacement*	
0 traits	0.0 % of total	0 traits	0.0 % of total
9.7 % of total traits		90.4 % of total traits	
Encope tamiamiensis vs *Mellita quinquiesperforata*			
Neoteny		*Acceleration*	
3 traits	7.9 % of total	21 traits	52.6 % of total
Progenesis		*Hypermorphosis*	
0 traits	0.0 % of total	8 traits	21.0 % of total
Post-Displacement		*Pre-Displacement*	
4 traits	10.5 % of total	3 traits	7.9 % of total
18.4 % of total traits		81.5 % of total traits	

CHAPTER 6
SUMMARY AND CONCLUSIONS

The Cenozoic fossil record of Florida is renowned world-wide for the abundance of material, the diversity of taxa, and the wealth of paleontological and paleoecological information that can be collected from the strata. The fossil invertebrate record is particularly good, especially for taxonomic groups like the molluscs and foraminifera, with some of the Neogene beds composed almost entirely of shell material. Fossil echinoderms are a significant component of several formations, including the Ocala Limestone and Suwannee Limestone from the Paleogene and the Tamiami Formation from the Neogene, while other units apparently had only sparse distributions according to the published record through 1994. My research has significantly changed our understanding of the diversity pattern of echinoderms, particularly in the transition from the Paleogene to the Neogene.

New Echinoderm Diversity Patterns

Most of the echinoderms reported as fossils are echinoids, with only very limited reports and descriptions of asteroids, ophiuroids, and crinoids. Several

new reports of ophiuroids and asteroids are included herein (see chapter 3), though most identifications are very limited since isolated ossicles are not normally reliable guides for lower taxonomic identifications. Most of the changes in diversity involve the echinoids as a group. When this project was started, the total echinoid diversity from the Middle Eocene through the Pleistocene was 68 species, whereas I now report the diversity to be 100 species. This represents an increase of nearly 50% over the previously published diversity, with the new records and new reported occurrences now accounting for 32% of the total record. The additional taxa reported and counted in this analysis are both new stratigraphic records for the state as well as any fossils I interpret to be new taxonomic species. Therefore, not all of the new additions are new taxa in an evolutionary context, yet even the newly reported occurrences of species are important to more fully understand the patterns of change temporally as well as spatially.

Another important change in echinoid diversity as a result of the research completed herein occurs across the Paleogene-Neogene boundary. The previously published diversity values were at eight species in the Oligocene and five species in the Miocene. I generate a much different pattern based on my revised data, so that the diversity increases from 11 species in the Oligocene to 22 species in the Miocene. This reflects a dramatic increase in diversity that I propose to be the primary result of collecting style rather than principally controlled by extinction, origination, or an environmental cause. Most of the taxa considered herein as new stratigraphic records and new taxonomic records in the

Miocene likely were recorded simply due to sampling of fragmented, incomplete specimens. Most paleontologists are interested in more complete specimens for biometric analysis or descriptive work. Fragmented fossils do not allow easy identifications to be completed and thus may not lend themselves as well for application to community analysis, paleoecology reconstruction, or species descriptions. Unfortunately, this has resulted in reported diversity of the Miocene to be very low, but clearly this is not true when small size-fractions or fragmented specimens are examined and documented for the fossil record.

I believe several other biases (in addition to collector bias) have contributed to the previously reported low diversity of the Miocene as well as the overall diversity pattern in the Cenozoic echinoids of Florida. The status of stratigraphic nomenclature and how such strata are defined greatly affects the values attributed to "new stratigraphic records" in the state. If one formation is subdivided into two distinct units, the echinoderms present in at least one of those units would, by definition, become a first reported occurrence of the species within that formation. Conversely, if consolidation of stratigraphic units occurs, it is possible that a species may be removed from the biostratigraphic distinction of a new report for a formation.

Mineralogical composition of the rock units can also influence the diversity pattern due to its influence on weathering and preservation potential of the fossils. In Florida, the general trend is for better preservation of echinoderms in carbonate rock units of the Paleogene and poorer preservation styles in Neogene siliciclastic units. The carbonate rock layers buffer acidic groundwater solutions,

thereby reducing dissolution or test degradation when the fossils is surrounded by the limestone sediment. Siliciclastic units, on the other hand, do not have an abundance of minerals that can buffer acidic solutions. This results in more effective chemical degradation by the acid when a carbonate fossil grain, such as tests and ossicles of echinoderms, comes in contact with acidic groundwater. The chemical reaction need not be complete in order to influence the physical strength and durability of the skeletal grain; partial dissolution may be enough to enhance the extent of breakage. This may help explain the predominance of fragmented and highly weathered fossils of all varieties in selected siliciclastic beds of Neogene units.

Several other biases affect the diversity record of echinoderms in Florida (discussed in Chapter 4), but perhaps not to the extent that sampling bias, stratigraphic nomenclature changes, and the diagenetic setting may have on the record. Regardless, one must be aware of such biases to accurately interpret the patterns present in the fossil record.

Taxonomic Implications

Another important result of the work completed is the collection of numerous fossils that appear to be new species of echinoderms. Relatively few specimens from Paleogene formations may be undescribed taxa, but the Neogene units (particularly of Miocene age) may have more than eight echinoid species awaiting formal description. In addition to the echinoids, several asteroid

and crinoid specimens remain unidentified to specific level and are possible new taxa.

The higher proportion of potential new species in the Paleogene likely is a function of few paleontologists closely examining the broken and disarticulated material associated with the formations. Descriptions of incomplete specimens often result in rather tentative identifications, so it is possible that even if such taxa had been collected in the past, they were discarded rather than described. In more recent years, technology improvements have provided the necessary tools to examine fragments in much greater detail. Scanning electron microscopy allows observation of ossicle and skeletal plate micromophology that are often distinctive for identification to lower taxonomic levels. Therefore, even the apparently “useless” isolated plate or radiole fragments may give clues to family, genus or species identification (see Donovan and Carby, 1989; Gordon and Donovan, 1992; and Dixon and Donovan, 1998 as examples).

Finally, biometric analysis of the selected mellitid species indicated several species may be too similar to justify unique species status. As an example, Encope macrophora (a species found in North and South Carolina) and Encope tamiamiensis (a species found in Florida) have nearly identical regression line slopes when various physical traits such test width are regressed with test length. The growth trajectories for such traits often are not statistically significant, and even when a statistical difference exists, one cannot discern a difference when looking at the hand sample. This tendency to name new species based purely upon geographic differences among populations rather

than significant morphological variance creates turmoil in the realm of taxonomic worker. I believe significant work can be done in the future to help clarify and resolve problems like this by combing statistical analyses with detailed qualitative characterizations.

What Work Lies Ahead?

I believe my work in biostratigraphy has just begun, and one of the most important components of the echinoderm biostratigraphy is to refine the stratigraphic resolution of the data I have gathered thus far. Most of the data are limited to formation or, in far less common cases, members of formations. Isolated data exist with measured section information available, but it is not common enough for most detailed tasks. My goal is to continue sampling stratigraphic units, looking for any fragmented or complete fossil material that may produce indications of greater diversity in the Florida units than we currently recognize. Measured sections, with lithologic descriptions and (ideally) petrography will allow enhance facies and biofacies distributions to be interpreted and utilized for paleoecology purposes.

A second component that I believe needs to be investigated is a broader picture of the echinoderm biostratigraphy. Cooke's work (1959) describing the Cenozoic echinoderms of the southeastern U.S. is over 40 years old. Much of his taxonomic work is out of date with respect to stratigraphic and geographic distributions of the echinoids. Numerous taxonomic revisions to his "cook(e)book of echinoid paleontology" require the database to be updated, and no one thus

far has compiled enough new data to make significant changes to his monograph. I believe the work I have done herein is at least a strong advance forward toward completing a revision, and this is a "big-picture" goal I have considered ever since I began consulting his publication for assistance in identifying my field samples of echinoids.

The goal of a dissertation is to learn how to ask appropriate questions, learn to solve any such questions, and to improve one's personal knowledge while contributing to the science as a whole. I may not know everything about echinoids or their relatives, but I do know that the more I learn about them, the greater my curiosity grows to learn more.

APPENDIX
ECHINOID BIOMETRIC TRAIT MEASUREMENTS

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
1	28204.01	75.66	75.60	3.17	2.87	32.10	2.37	1.00
2	28204.02	45.55	44.98	3.13	2.87	19.55	1.39	1.09
3	28204.03	34.23	33.92	2.40	2.13	14.10	•	•
4	28204.04	33.38	32.67	1.80	1.66	13.98	1.37	0.91
5	28204.05	25.64	27.67	1.90	1.85	10.87	1.42	0.83
6	28204.06	21.79	21.80	1.29	1.16	9.29	0.87	0.48
7	30401.01	72.21	71.85	2.76	2.55	31.72	2.18	1.28
8	30401.02	44.45	45.46	2.84	2.65	18.30	•	•
9	30401.03	42.79	42.76	1.66	1.49	19.15	1.43	0.86
10	30401.04	43.18	44.65	2.45	2.18	18.36	1.70	1.13
11	30401.05	38.15	39.38	2.50	2.27	15.57	1.49	1.06
12	30401.06	34.62	35.02	1.80	1.75	14.13	1.48	0.81
13	30401.07	30.14	31.03	1.80	1.72	12.59	1.58	0.91
14	30401.08	27.64	28.84	1.67	1.43	11.68	1.24	0.78
15	30401.09	20.72	21.34	1.32	1.27	8.55	0.86	0.60
16	30401.10	•	•	1.52	1.44	•	1.34	0.68
17	28207.01	74.34	73.83	3.04	2.94	32.43	1.63	1.14
18	28207.02	64.52	65.04	2.48	2.24	29.10	1.54	1.19
19	28207.03	59.48	•	3.28	3.04	26.67	2.36	1.06
20	21435.01	74.10	75.99	•	•	•	•	•
21	24518.01	36.42	37.70	1.79	1.63	15.04	1.70	0.58
22	24518.02	27.76	27.54	1.67	1.62	11.86	0.96	0.87
23	28208.01	35.54	34.87	2.03	1.73	15.40	1.28	0.81
24	28208.02	33.59	34.03	2.07	1.91	13.53	1.42	0.90
25	28208.03	40.99	•	1.82	1.79	17.75	1.71	1.02
26	28208.04	31.82	32.66	2.36	2.10	13.10	1.24	0.90
27	28208.05	•	33.59	1.47	1.42	14.35	1.72	0.68
28	21312.01	55.79	56.80	2.94	2.73	25.17	2.18	1.18
29	21312.02	40.30	40.04	2.47	2.33	17.01	1.20	0.95
30	21312.03	34.62	•	1.95	1.80	14.33	1.42	0.78
31	21312.04	28.65	29.14	1.32	1.28	12.35	1.40	0.63
32	21312.05	23.27	23.68	1.57	1.73	9.98	1.02	0.85
33	21312.06	20.06	20.16	1.29	1.38	8.50	0.96	0.60
34	21312.07	18.83	19.25	1.16	1.39	7.92	0.99	0.67
35	21313.01	64.51	63.51	2.56	2.43	27.66	1.85	1.15
36	21313.02	58.29	58.31	2.66	2.55	25.60	1.48	0.91
37	21313.03	65.03	65.87	2.78	2.67	28.57	1.75	1.19
38	21313.04	33.37	34.49	1.48	1.49	13.89	1.58	0.77
39	21313.05	31.54	32.76	2.00	1.82	13.43	1.05	0.80
40	21313.06	30.37	30.30	1.58	1.47	12.92	1.32	0.80
41	21313.07	30.94	30.35	1.48	1.34	13.29	1.04	0.68
42	21313.08	28.63	28.32	2.34	2.15	11.84	0.99	0.91
43	21313.09	28.66	28.63	1.49	1.40	11.92	1.38	0.62
44	21313.10	26.41	27.10	1.66	1.48	11.48	1.30	0.68
45	21313.11	21.33	21.38	1.63	1.48	8.20	1.18	0.82
46	21443.01	77.49	76.82	•	•	35.10	•	•
47	21443.02	•	30.93	1.80	1.86	•	1.06	0.93
48	21443.03	25.40	25.38	1.65	1.57	10.50	0.93	0.91

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
49	21443.04	24.89	26.30	1.19	1.24	10.78	0.83	0.48
50	21443.05	25.04	25.90	1.06	0.97	10.31	1.37	0.50
51	21443.06	22.96	22.74	1.02	1.04	9.62	1.23	0.58
52	21443.07	22.00	23.62	1.23	1.14	9.29	0.83	0.44
53	21443.08	19.38	19.54	1.21	0.91	9.05	0.62	0.44
54	21443.09	19.53	20.75	1.09	1.09	8.50	1.06	0.57
55	21443.10	18.66	18.69	0.99	0.97	7.98	0.86	0.48
56	21443.11	16.63	17.64	1.09	1.18	7.06	0.82	0.45
57	21443.12	14.45	14.73	1.07	1.01	6.04	0.71	0.26
58	40360.01	43.59	42.32	2.23	2.13	19.15	1.60	1.24
59	40362.01	41.41	42.18	1.82	1.65	18.07	1.96	0.72
60	40363.01	58.57	58.26	2.71	2.74	25.80	1.85	1.15
61	40364.01	38.64	38.49	2.27	2.13	16.82	1.89	0.80
62	40385.01	32.18	32.61	1.54	1.49	14.30	1.32	0.76
63	40386.01	44.05	44.74	2.31	2.18	18.05	2.15	0.73
64	40387.01	32.82	32.62	1.73	1.84	13.89	1.07	0.92
65	40366.01	34.15	33.27	2.04	1.93	14.84	1.46	0.74
66	40367.01	76.70	76.16	3.12	3.11	33.60	1.96	1.15
67	40421.01	36.96	35.17	1.62	1.67	15.12	1.79	0.66
68	40422.01	42.29	41.60	2.62	2.43	18.07	2.00	1.07
69	40371.01	53.61	52.92	3.25	2.89	22.60	2.31	1.14
70	40372.01	•	34.18	1.67	1.42	13.94	1.94	0.63
71	40373.01	40.47	39.44	2.26	2.26	17.17	1.38	0.92
72	40374.01	33.38	32.86	2.13	1.82	13.88	2.18	1.01
73	40370.01	•	61.68	2.69	2.45	28.61	•	•
74	40375.01	36.39	37.54	2.12	2.03	15.36	1.61	0.87
75	40389.01	36.22	37.38	1.54	1.51	15.60	1.60	0.83
76	40368.01	43.24	•	2.04	1.84	18.93	1.63	0.77
77	40431.01	79.34	80.44	3.22	3.25	35.59	•	•
78	40380.01	27.86	28.27	1.62	1.44	11.98	1.52	0.59
79	40379.01	30.44	30.49	2.10	2.13	12.70	1.23	0.83
80	40365.01	26.98	28.00	1.81	1.75	11.41	1.06	0.63
81	40358.01	26.61	26.72	1.23	1.21	11.40	1.02	0.67
82	40359.01	28.89	28.63	•	•	12.02	1.18	0.78
83	40388.01	24.09	24.98	1.44	1.20	10.32	•	•
84	40369.01	28.75	29.01	1.52	1.62	12.38	1.25	0.74
85	40417.01	42.84	•	1.48	1.65	19.20	2.38	0.69
86	40418.01	35.19	•	1.70	1.67	14.42	1.16	0.76
87	40419.01	30.75	32.02	1.99	2.00	12.70	1.20	0.86
88	40420.01	42.13	42.17	1.90	1.90	18.04	1.96	0.68
89	40432.01	78.93	78.91	2.89	3.08	34.31	•	•
90	40384.01	25.47	•	1.60	1.49	10.84	1.51	0.76
91	40383.01	29.01	29.54	1.43	1.57	12.66	1.25	0.71
92	40381.01	27.41	27.76	1.47	1.33	11.88	1.80	0.60
93	40391.01	25.42	27.03	1.11	1.20	11.37	1.27	0.60
94	40390.01	27.00	26.79	1.62	1.56	11.43	1.53	0.86
95	40377.01	27.12	26.23	•	1.56	11.11	1.27	0.66
96	40376.01	28.47	28.00	1.54	1.27	12.11	1.42	0.63

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
97	40361.01	25.45	26.17	1.21	1.21	11.18	1.23	0.53
98	40429.01	80.03	79.59	3.04	2.79	36.37	1.98	1.32
99	40430.01	59.75	60.24	2.54	2.36	25.90	2.00	0.99
100	40428.01	70.42	70.14	3.02	2.95	30.55	2.18	1.39
101	40433.01	54.67	55.39	2.36	2.27	23.87	1.99	0.96
102	29684.01	64.68	63.61	2.64	2.59	29.19	1.86	0.88
103	29684.02	30.06	30.42	2.13	2.00	12.57	1.14	0.77
104	29684.03	27.64	26.53	1.27	1.20	11.72	1.20	0.69
105	40416.01	25.69	27.02	1.68	1.68	10.71	1.15	0.71
106	40415.01	26.31	27.20	1.01	•	•	1.01	0.71
107	40414.01	28.67	29.65	1.57	1.53	12.11	1.25	0.67
108	40413.01	26.23	27.66	1.52	1.56	10.92	0.96	0.67
109	40411.01	25.60	25.85	1.09	1.09	10.65	0.97	0.66
110	40409.01	31.40	30.91	1.81	1.71	13.39	1.49	0.83
111	40382.01	26.49	27.50	1.79	1.73	11.13	1.34	0.71
112	40434.01	22.41	22.19	1.33	1.34	9.77	1.14	0.68
113	40426.01	22.59	23.11	1.19	1.11	9.56	0.96	0.58
114	40425.01	29.57	29.38	1.79	1.76	12.16	1.11	0.78
115	40424.01	21.50	21.64	1.09	1.14	8.92	0.86	0.62
116	40423.01	28.18	28.11	1.79	1.77	11.91	1.27	0.97
117	40412.01	20.72	20.68	1.21	1.11	8.99	1.01	0.53
118	40392.01	18.45	18.40	1.14	1.06	7.65	0.91	0.43
119	40378.01	18.33	17.78	1.18	1.13	7.79	0.83	0.59
120	13753.01	62.86	66.15	2.73	2.76	26.84	1.91	1.27
121	13753.02	48.72	48.97	2.29	2.18	21.14	1.47	0.77
122	13753.03	27.68	28.04	1.32	1.40	11.51	1.16	0.82
123	13753.04	24.56	25.31	1.28	1.25	10.40	0.90	0.45
124	13753.05	22.97	22.64	1.30	1.44	9.18	0.96	0.68
125	13753.06	23.48	23.20	1.11	1.20	9.77	0.90	0.52
126	13753.07	19.35	19.34	1.10	1.05	8.07	0.92	0.34
127	13075.01	83.08	83.88	•	•	•	•	•
128	29670.01	36.75	38.13	1.66	1.58	15.35	1.96	0.77
129	13076.01	76.86	76.70	2.70	2.73	34.02	•	•
130	465436.01	105.96	103.72	•	•	•	•	•
131	465463.01	60.52	59.09	2.56	2.26	26.63	2.46	1.01
132	465464.01	71.95	70.00	•	•	32.38	4.80	1.47
133	465449.01	57.91	57.92	3.04	2.70	26.06	2.57	1.27
134	465440.01	56.99	56.19	2.00	1.72	25.59	2.66	0.92
135	465458.01	59.98	58.35	3.14	3.28	27.38	1.87	1.42
136	465467.01	62.40	62.38	•	•	•	•	•
137	465444.01	22.47	22.80	1.16	1.16	9.84	0.91	0.57
138	465466.01	69.88	68.68	3.53	3.65	31.29	2.17	0.96
139	465451.01	65.12	63.24	2.81	2.66	29.37	2.01	1.20
140	465465.01	55.49	55.29	2.81	2.66	24.28	3.46	0.97
141	465456.01	21.64	21.03	1.77	2.01	8.53	1.38	0.57
142	465448.01	65.64	65.04	2.32	2.59	30.22	1.70	1.11
143	465445.01	•	126.96	•	•	•	•	•
144	465443.01	25.47	25.40	1.33	1.28	10.87	0.83	0.60

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
145	465442.01	31.40	31.59	1.56	1.48	13.42	1.02	0.66
146	465468.01	28.82	29.69	1.42	1.33	12.71	1.11	0.97
147	438118.01	70.56	72.72	•	•	•	•	•
148	438188.02	67.50	65.18	•	•	•	2.87	1.11
149	1.01	107.04	114.49	3.16	2.98	48.43	5.35	1.35
150	2.01	101.42	103.73	3.74	3.68	46.65	5.37	1.33
151	3.01	96.60	98.24	3.40	3.14	42.30	5.16	1.47
152	5.01	118.42	121.81	4.15	3.71	53.19	3.93	1.63
153	9.01	82.20	84.88	2.80	3.03	35.59	2.93	1.31
154	10.01	102.78	104.44	3.53	3.67	46.01	5.23	0.99
155	11.01	116.09	120.08	3.67	3.45	53.27	4.51	1.52
156	12.01	76.57	76.15	•	•	33.40	•	•
157	16.01	95.47	•	3.40	3.13	42.77	4.92	1.07
158	17.01	101.89	106.87	3.14	2.87	45.97	5.81	1.38
159	19.01	83.64	89.30	3.31	3.21	38.81	4.76	1.25
160	20.01	115.61	120.02	4.03	3.56	53.74	3.25	1.31
161	21.01	106.29	111.01	3.50	3.50	48.86	7.08	1.10
162	22.01	94.38	95.70	2.99	2.94	42.42	3.10	1.20
163	23.01	83.52	86.30	3.22	3.13	37.17	2.82	1.36
164	24.01	91.19	93.61	3.60	3.26	41.31	5.20	1.18
165	25.01	113.34	116.31	•	2.55	50.10	3.25	1.66
166	26.01	125.05	•	3.85	3.72	54.85	2.49	1.42
167	27.01	95.73	96.85	3.03	2.95	42.98	6.97	1.19
168	28.01	87.03	•	3.34	3.11	38.67	4.10	1.19
169	32.01	91.03	91.05	3.56	3.13	41.84	4.61	1.13
170	33.01	•	72.35	3.52	3.32	39.98	4.97	1.51
171	35.01	81.41	84.22	2.87	2.91	36.38	2.88	1.15
172	36.01	111.34	117.41	3.55	3.44	48.91	2.49	1.34
173	37.01	103.33	111.49	3.79	3.54	48.51	4.14	1.01
174	38.01	•	93.24	3.13	3.01	41.60	3.88	1.72
175	39.01	79.69	79.24	3.04	2.85	35.39	4.07	1.06
176	44.01	104.08	110.66	3.32	3.17	49.86	3.23	0.98
177	46.01	73.99	76.10	3.05	2.93	33.19	2.49	1.31
178	49.01	96.84	•	3.31	3.21	44.56	5.28	1.20
179	51.01	96.93	101.51	3.14	3.19	43.41	4.58	1.56
180	55.01	103.18	108.16	2.93	3.27	46.02	6.04	1.16
181	58.01	86.71	•	2.91	2.58	40.77	3.87	0.99
182	69.01	95.73	95.01	3.14	2.97	43.25	2.74	1.43
183	70.01	101.10	104.53	3.34	3.20	45.42	3.10	1.25
184	72.01	90.87	93.29	3.30	3.19	41.19	2.29	1.09
185	77.01	111.10	113.54	3.45	3.54	53.18	3.52	1.34
186	79.01	88.22	88.77	3.41	3.15	40.07	5.37	1.21
187	81.01	100.82	103.68	3.21	3.10	47.32	2.01	1.05
188	89.01	112.41	115.17	3.45	3.17	52.56	2.44	1.22
189	96.01	99.30	104.63	3.04	2.93	46.74	4.57	1.24
190	97.01	95.72	100.12	3.67	3.23	42.14	2.60	•
191	98.01	93.38	97.25	2.98	2.73	41.49	5.88	1.48
192	99.01	88.40	91.14	3.49	3.36	41.09	3.61	1.19

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
193	105.01	99.87	105.44	3.61	3.18	47.68	5.32	1.38
194	108.01	66.85	68.96	2.93	2.94	30.30	3.61	1.06
195	109.01	98.71	101.74	3.70	3.59	43.11	6.88	1.32
196	116.01	81.61	84.44	3.08	3.04	37.33	5.49	1.34
197	118.01	105.13	106.93	3.46	3.31	46.72	5.43	1.34
198	119.01	87.07	95.60	3.28	3.08	38.96	4.27	1.32
199	124.01	92.90	96.48	2.95	3.06	41.50	5.90	1.29
200	127.01	91.82	98.31	3.17	3.16	41.94	5.84	1.37
201	129.01	93.86	95.90	3.38	3.08	42.71	2.15	1.20
202	141.01	96.15	105.77	3.65	3.69	46.03	5.27	1.06
203	143.01	72.64	74.72	2.95	2.74	33.66	3.62	1.33
204	144.01	118.91	123.97	4.06	3.94	52.31	3.36	1.16
205	146.01	67.18	68.70	2.89	2.62	31.57	2.99	1.05
206	147.01	130.27	134.54	3.78	3.70	59.50	5.21	1.51
207	150.01	91.27	92.72	3.07	2.95	41.30	4.07	1.33
208	169.01	88.14	90.78	3.31	3.30	37.97	4.60	1.54
209	171.01	61.50	•	2.63	2.47	27.21	2.36	0.97
210	174.01	71.99	72.54	2.76	2.65	31.75	2.06	1.09
211	184.01	93.92	97.87	3.56	3.53	41.60	1.95	1.09
212	185.01	92.10	93.13	3.12	3.10	41.76	3.45	1.37
213	194.01	100.73	102.27	3.31	3.18	44.98	3.60	1.31
214	201.01	102.76	103.82	3.18	3.40	45.86	4.32	1.44
215	202.01	94.45	97.14	3.46	3.37	43.97	3.42	1.27
216	204.01	•	107.14	3.77	3.54	45.67	3.03	1.27
217	207.01	100.71	105.22	3.56	3.34	42.48	2.22	0.96
218	208.01	100.04	106.86	3.86	3.46	47.01	2.50	1.33
219	209.01	100.94	102.94	3.33	3.03	44.62	3.25	1.43
220	210.01	90.18	91.89	3.24	3.18	40.05	3.17	1.44
221	211.01	90.78	93.64	3.35	3.27	40.15	2.23	1.38
222	212.01	110.13	•	3.47	3.25	47.76	4.42	1.32
223	465472.01	100.83	106.95	•	•	•	•	•
224	146726.01	118.35	•	•	•	•	5.76	1.98
225	465470.01	101.57	109.23	•	•	•	•	•
226	465470.02	64.92	68.70	4.06	3.12	28.05	3.78	1.21
227	154281.01	151.30	•	5.23	4.96	69.10	5.47	1.57
228	146720.01	128.73	139.34	5.21	4.30	56.66	5.79	1.63
229	146644.01	119.84	128.48	5.08	4.41	51.40	•	1.27
230	465471.01	100.46	104.92	3.70	4.01	42.68	3.91	1.07
231	146724.01	•	131.95	5.46	5.20	50.83	4.07	1.67
232	465469.01	93.09	95.51	3.47	3.45	40.33	3.36	0.99
233	21324.01	90.69	84.22	3.94	3.65	39.01	3.03	1.67
234	21324.02	91.49	91.31	•	4.48	•	•	2.20
235	21324.03	94.19	•	3.84	3.64	38.84	2.99	2.08
236	21324.04	87.35	80.22	4.81	4.85	34.82	2.48	2.28
237	21324.05	83.45	78.90	3.91	3.63	35.50	2.47	1.32
238	21324.06	70.10	65.41	3.27	3.14	28.24	2.38	1.34
239	21324.07	56.93	55.84	3.02	2.99	24.20	2.33	1.20
240	24511.01	74.02	71.19	4.29	4.34	30.84	2.64	1.57

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
241	24511.02	59.76	55.65	3.70	3.58	24.51	1.76	1.18
242	24511.03	54.55	47.98	3.47	3.40	20.32	1.57	1.42
243	24511.04	47.61	43.87	•	•	•	1.94	1.29
244	24511.05	45.16	42.90	3.32	3.07	17.98	1.93	1.20
245	24511.06	42.73	40.01	2.98	3.00	17.61	1.32	1.11
246	24511.07	43.28	40.00	2.79	2.76	16.71	1.43	1.06
247	24511.08	40.65	37.45	2.80	2.90	16.30	1.90	1.20
248	24511.09	41.00	36.46	3.13	3.18	16.59	1.99	0.96
249	24511.10	39.58	35.89	2.83	2.90	15.62	1.25	1.05
250	24511.11	38.58	36.37	2.71	2.80	14.75	1.28	1.06
251	24511.12	39.12	35.10	3.17	3.08	15.68	1.67	1.11
252	24511.13	36.28	33.33	2.67	2.54	14.36	1.80	1.05
253	24511.14	37.04	33.94	2.62	2.79	14.49	1.32	0.95
254	24511.15	25.88	24.96	2.01	1.96	10.32	1.23	0.74
255	24511.16	35.80	33.95	2.41	2.70	14.03	1.38	1.09
256	24511.17	32.48	30.64	2.71	2.71	13.22	1.09	1.06
257	24511.18	33.33	30.73	2.83	2.67	13.77	1.20	1.00
258	24511.19	33.42	29.28	2.69	2.61	13.13	1.13	0.96
259	24511.20	30.22	28.49	2.57	2.23	11.73	1.48	0.93
260	24511.21	29.81	28.21	2.05	2.18	12.50	1.10	0.85
261	24511.22	29.66	26.80	2.09	2.10	11.83	1.52	0.91
262	24511.23	21.90	20.42	1.79	1.85	8.83	1.09	0.81
263	21212.01	68.55	67.53	3.61	3.80	27.43	2.51	1.78
264	21213.01	74.12	69.62	3.57	3.95	29.93	1.99	1.62
265	21214.01	54.58	51.10	3.40	3.24	22.61	1.79	1.28
266	21215.01	100.44	98.03	•	•	•	3.67	2.30
267	21216.01	100.97	95.97	4.07	4.10	42.35	3.57	1.85
268	21217.01	109.52	106.24	4.73	5.05	46.58	3.87	2.39
269	21218.01	102.94	99.01	5.71	6.03	41.37	4.54	1.95
270	21219.01	94.64	96.65	4.18	3.92	39.17	3.03	1.47
271	21220.01	91.65	92.75	•	•	•	3.04	1.68
272	21221.01	76.34	70.14	3.73	3.96	31.30	2.50	2.27
273	21223.01	70.70	64.08	3.71	4.10	28.92	2.46	1.64
274	21224.01	62.11	60.85	3.19	3.36	25.09	2.44	1.31
275	21225.01	66.03	63.76	3.54	3.65	27.60	2.11	1.66
276	21226.01	43.78	41.50	2.85	2.84	17.26	1.86	1.51
277	21227.01	68.12	66.27	4.13	4.05	28.97	3.18	1.66
278	21228.01	62.49	59.39	3.63	3.52	25.43	2.12	1.62
279	21229.01	49.73	43.19	3.19	3.41	19.18	1.84	1.30
280	21230.01	69.20	64.14	4.20	4.27	27.07	2.94	1.70
281	21231.01	55.10	52.65	3.53	3.60	22.30	2.42	1.52
282	21232.01	68.17	65.02	3.70	3.85	27.38	3.01	1.31
283	21233.01	66.33	63.60	3.68	3.61	27.09	2.02	1.56
284	21234.01	62.98	60.26	3.10	2.99	26.89	1.75	1.23
285	21235.01	48.64	44.31	3.37	3.34	20.36	1.66	1.38
286	21236.01	62.77	62.87	3.46	3.65	24.75	2.26	1.49
287	21237.01	57.10	50.66	3.25	3.06	23.12	1.93	1.44
288	21238.01	50.42	47.38	•	•	21.04	1.81	1.39

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
289	21239.01	48.83	45.67	3.07	2.99	19.49	1.54	1.24
290	21240.01	57.94	55.96	4.69	4.60	21.93	2.16	1.53
291	21241.01	49.44	45.30	3.22	3.16	20.11	1.53	1.13
292	21242.01	42.62	41.24	•	•	•	•	1.13
293	21243.01	48.51	44.18	3.14	3.15	18.17	2.10	1.54
294	21244.01	44.53	40.92	2.93	3.10	18.14	1.57	1.23
295	21245.01	51.96	49.75	3.07	3.11	21.09	2.03	1.36
296	21246.01	45.32	42.65	3.13	3.05	19.32	1.65	1.17
297	21247.01	41.65	38.62	2.83	2.61	16.67	1.59	1.32
298	21248.01	44.06	41.25	2.89	3.32	18.34	1.70	1.23
299	21249.01	45.33	42.48	2.78	3.02	18.49	1.34	1.12
300	21250.01	38.38	37.58	2.65	2.54	15.89	1.63	1.12
301	21251.01	39.74	38.81	2.59	2.65	16.32	2.06	1.07
302	21252.01	36.78	35.51	2.70	2.65	15.04	1.19	0.99
303	21253.01	39.06	37.01	2.59	2.74	15.89	1.53	1.13
304	21254.01	32.87	30.80	2.50	2.51	13.11	1.40	0.90
305	21255.01	35.59	33.95	2.60	2.82	13.89	1.20	0.95
306	21256.01	34.20	31.69	2.51	2.62	13.83	1.57	0.88
307	21257.01	35.50	35.16	1.79	1.80	15.75	1.37	0.85
308	21258.01	34.90	33.21	2.30	2.26	13.99	2.16	0.98
309	21259.01	38.94	36.91	2.70	2.73	16.01	1.49	1.44
310	21260.01	38.13	35.26	2.62	2.43	15.07	1.38	1.21
311	21261.01	36.37	34.59	2.40	2.63	14.43	1.50	1.21
312	21262.01	40.28	37.97	2.58	2.56	15.36	1.31	0.93
313	21263.01	40.46	37.89	2.71	2.82	16.86	1.66	1.22
314	21264.01	45.53	42.75	•	2.94	18.49	1.32	1.07
315	21265.01	32.54	30.36	2.28	2.24	13.21	1.16	0.92
316	21266.01	33.34	30.32	2.26	2.40	13.42	1.76	1.12
317	21267.01	39.26	37.40	2.81	2.88	15.15	1.44	1.14
318	21268.01	34.26	32.89	2.12	2.37	13.47	1.11	0.85
319	21269.01	31.52	29.65	2.26	2.32	12.84	1.04	0.86
320	21270.01	30.61	28.48	2.63	2.31	12.47	1.85	•
321	21271.01	30.06	27.44	2.52	2.61	12.07	1.48	1.12
322	21272.01	35.77	34.14	2.68	2.80	14.74	1.39	1.09
323	21273.01	28.03	26.16	1.97	2.02	11.17	1.33	0.85
324	21274.01	30.98	29.29	2.25	2.24	12.33	1.47	0.95
325	21275.01	25.98	24.67	1.79	2.22	10.48	1.11	0.85
326	21276.01	23.86	22.86	2.01	1.98	9.04	1.28	0.83
327	21277.01	24.26	22.91	1.81	1.86	9.88	1.20	0.84
328	21278.01	22.94	21.57	1.70	1.83	9.57	1.11	0.85
329	21279.01	23.20	20.75	1.94	1.97	9.31	0.99	0.77
330	21280.01	21.02	20.29	1.72	1.73	8.69	1.20	0.91
331	21281.01	21.53	20.27	1.75	1.74	9.04	1.15	0.84
332	21282.01	20.75	19.08	1.55	1.60	8.57	1.24	0.79
333	21283.01	20.16	18.87	1.67	1.77	8.48	1.07	0.81
334	28219.01	100.98	97.54	4.93	4.78	41.97	2.37	1.98
335	28219.02	70.34	65.15	3.71	3.83	29.86	1.92	1.71
336	28219.03	57.74	57.08	3.54	3.49	23.38	2.24	1.78

#	UF, USNM #	TL	TW	PSL	PSW	PSP	PPL	PPW
337	28219.04	55.98	51.42	3.36	3.51	22.68	2.22	1.59
338	28219.05	51.48	49.41	3.19	3.11	20.36	1.68	1.33
339	28219.06	49.11	46.88	3.39	3.42	18.27	1.87	1.30
340	28219.07	48.27	44.98	3.19	3.22	20.24	1.78	1.49
341	28219.08	47.07	43.98	3.02	3.01	19.02	1.72	1.26
342	28219.09	45.25	46.52	2.18	2.43	18.83	1.63	0.95
343	28219.10	43.86	42.71	2.58	2.80	17.79	1.72	1.24
344	28219.11	42.07	38.18	2.82	2.79	16.97	1.54	1.24
345	28219.12	39.63	37.07	2.50	2.45	16.32	1.66	1.10
346	28219.13	38.27	35.64	2.61	2.68	15.55	1.38	1.06
347	28219.14	33.68	31.28	2.54	2.53	13.33	1.15	0.88
348	28219.15	27.51	25.73	2.20	2.16	11.16	1.57	0.84
349	28219.16	26.40	24.64	2.06	2.11	10.73	1.16	0.88
350	28219.17	25.23	24.65	1.94	2.03	10.81	0.85	0.57
351	28219.18	24.08	23.29	1.72	1.94	10.01	1.28	0.87
352	28219.19	21.08	19.68	1.80	1.80	8.88	1.03	0.83
353	28219.20	16.76	14.88	1.64	1.62	6.65	0.91	0.67
354	465487.01	65.43	66.66	3.17	3.08	29.17	2.22	1.39
355	465487.02	87.02	82.14	2.45	2.60	39.52	•	•
356	465487.03	89.10	88.78	•	•	•	•	•
357	465487.04	86.51	81.87	•	•	•	•	•
358	465487.05	•	•	•	•	•	•	•
359	465487.06	89.92	89.20	•	•	•	2.67	1.77
360	465487.07	97.02	92.63	•	•	•	•	•
361	465487.08	90.24	•	•	•	•	•	•
362	465486.01	67.84	65.86	2.45	2.37	31.77	2.22	1.15
363	465486.02	63.39	65.74	•	•	•	•	•
364	154280.01	79.13	69.83	4.78	4.66	29.29	•	•
365	2512.01	66.97	61.18	•	•	•	3.07	1.99
366	2512.02	31.30	28.53	2.09	2.08	12.19	1.42	1.07
367	2512.03	28.62	25.71	2.40	2.19	10.37	1.47	0.96
368	2512.04	27.31	24.77	2.92	3.04	10.32	•	•
369	2512.05	26.14	23.95	2.24	2.31	10.13	1.66	1.00
370	145411.01	89.16	77.25	•	•	33.64	•	•
371	12900.01	90.91	•	•	•	•	1.24	1.16
372	12901.01	143.29	139.52	5.01	4.27	66.26	•	•

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
1	7.31	34.11	17.86	3.16	10.26	12.82	13.52	12.80	13.41
2	5.86	21.32	10.29	3.06	7.03	8.03	8.47	8.14	9.05
3	4.45	15.29	8.50	1.98	5.44	•	•	•	•
4	3.86	15.43	7.46	1.98	4.39	5.34	6.69	6.29	5.90
5	3.50	11.77	5.28	2.18	4.59	4.41	4.66	•	5.35
6	2.69	9.98	3.78	1.38	4.05	•	•	•	•
7	5.67	32.66	16.53	2.29	10.19	11.92	13.22	12.34	13.80
8	5.51	19.96	8.06	2.42	7.97	8.14	8.64	7.01	8.50
9	3.92	19.58	8.61	2.75	6.18	6.31	6.69	•	6.80
10	5.27	19.11	10.08	3.35	7.06	8.34	8.97	7.23	8.53
11	5.05	17.25	8.53	2.97	6.07	6.65	7.55	•	•
12	3.31	15.58	7.39	1.90	5.74	6.60	7.09	6.33	7.32
13	3.68	13.75	4.49	1.60	5.76	6.18	5.96	4.82	6.13
14	3.35	12.39	5.65	1.95	5.02	5.85	6.00	5.61	5.81
15	2.48	9.37	3.89	1.67	3.67	•	•	•	•
16	3.46	•	7.31	1.77	5.48	5.61	6.17	5.14	5.16
17	7.01	33.92	20.25	5.02	8.12	12.89	12.73	11.65	12.42
18	6.03	31.29	13.43	2.62	8.29	11.22	11.45	11.08	12.01
19	6.57	28.42	12.72	2.66	9.66	10.78	11.32	9.82	10.79
20	•	34.30	16.76	3.60	10.13	12.72	•	•	•
21	3.49	16.38	6.56	1.62	6.09	6.14	5.89	•	6.01
22	3.91	12.39	5.58	1.98	5.63	5.34	5.51	5.13	5.77
23	4.11	16.58	6.21	1.68	6.07	6.38	6.95	6.50	7.16
24	4.30	15.20	7.78	2.46	5.48	6.22	7.37	5.53	7.11
25	3.74	18.85	8.47	2.05	5.89	6.68	•	•	6.28
26	4.15	14.88	6.65	2.46	5.35	6.27	6.81	6.26	6.94
27	3.09	14.99	6.18	1.68	5.49	•	6.61	6.42	6.56
28	6.70	26.72	11.55	3.58	9.25	10.56	11.60	9.56	11.58
29	5.05	19.07	8.42	2.38	5.88	7.15	7.78	•	7.23
30	3.96	15.11	6.74	1.90	5.89	6.45	•	•	•
31	2.83	13.27	5.00	1.75	4.77	•	•	5.91	•
32	3.32	10.57	4.77	2.18	4.26	4.64	4.53	•	4.82
33	2.92	9.34	3.50	1.43	3.88	4.36	5.00	•	4.59
34	2.42	8.38	3.35	1.46	4.08	3.87	•	•	4.27
35	6.70	29.41	15.16	2.60	8.71	10.82	11.06	10.09	10.28
36	5.89	27.63	15.10	2.97	7.20	10.32	9.76	9.82	9.90
37	6.45	30.89	15.20	3.08	8.57	11.43	11.91	10.03	11.58
38	2.98	14.90	8.49	1.71	4.77	5.10	5.91	5.80	6.43
39	4.12	14.73	5.49	1.81	5.43	5.68	6.24	•	6.50
40	3.25	13.90	5.34	1.57	5.20	•	5.47	•	•
41	3.00	14.05	6.27	1.80	4.62	5.27	5.56	•	5.25
42	4.54	13.38	6.35	2.14	4.74	5.58	6.04	5.60	6.29
43	3.08	13.32	7.17	2.03	4.17	6.50	6.78	•	6.40
44	3.27	13.04	5.15	1.99	4.26	4.87	5.06	•	5.75
45	3.17	9.49	4.17	1.66	4.07	4.27	•	•	•
46	•	•	18.00	4.41	•	12.14	13.98	13.16	13.85
47	3.84	•	6.52	2.04	5.42	5.96	5.79	•	5.89
48	3.31	11.51	6.01	2.20	4.15	4.24	4.82	4.59	4.76

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
49	2.94	11.58	5.02	1.77	4.14	4.97	4.67	•	5.13
50	2.56	10.99	5.52	1.51	4.61	5.00	4.74	4.47	4.87
51	2.51	10.80	4.11	1.38	3.69	4.14	4.68	4.11	3.67
52	2.56	10.27	4.14	1.21	3.61	•	•	•	•
53	2.41	10.08	3.16	0.99	3.40	•	•	•	•
54	2.59	8.85	2.79	1.47	3.87	•	•	•	•
55	2.18	8.43	3.73	1.53	3.28	•	•	•	•
56	2.29	8.03	3.27	1.66	3.09	•	•	•	•
57	2.15	6.80	2.01	1.21	2.92	•	•	•	•
58	4.50	20.01	9.19	2.26	7.12	•	8.61	•	8.31
59	3.60	19.10	8.25	1.95	6.29	8.68	9.34	9.53	9.39
60	5.48	27.97	13.70	2.60	8.17	11.06	10.90	9.60	11.16
61	4.78	17.91	7.36	2.57	6.36	7.51	7.48	6.71	7.81
62	3.69	•	6.19	1.13	•	6.32	6.92	6.62	7.13
63	4.86	20.04	9.34	2.38	7.79	7.72	8.30	•	8.57
64	4.71	14.64	7.84	2.19	5.89	6.88	7.64	6.22	7.55
65	4.03	15.87	6.87	2.56	5.99	6.99	6.71	•	6.80
66	7.25	35.89	18.99	3.40	10.24	13.20	14.23	12.66	14.22
67	3.39	16.76	8.89	2.10	5.51	6.32	6.76	6.01	6.80
68	4.88	18.91	9.62	2.07	6.75	7.67	7.96	6.47	7.96
69	5.88	24.68	14.09	3.30	7.73	10.23	10.22	8.78	10.84
70	3.39	15.07	6.60	1.72	6.61	6.59	7.21	6.47	7.31
71	5.01	19.58	8.61	2.65	5.96	7.59	8.10	7.22	8.15
72	3.25	15.06	5.48	1.53	6.57	6.12	5.96	•	•
73	•	26.44	13.43	2.48	7.41	11.48	10.89	10.40	11.16
74	4.27	17.03	7.36	2.40	6.33	•	7.06	•	7.18
75	3.22	16.99	7.26	2.45	5.25	5.94	6.43	•	6.45
76	4.52	19.97	9.20	2.28	6.84	7.06	7.26	7.01	7.92
77	7.74	36.32	20.91	2.67	9.90	13.18	13.74	14.16	14.27
78	3.58	13.06	4.90	1.87	5.54	•	•	•	•
79	4.14	14.08	7.11	2.24	5.20	5.71	5.84	5.23	6.24
80	3.77	12.31	5.34	2.05	5.13	5.44	5.91	5.48	6.47
81	2.85	12.52	4.30	1.49	4.11	4.81	5.14	4.59	4.97
82	3.17	12.78	5.88	1.71	5.19	5.13	•	•	•
83	•	11.21	3.92	1.51	4.35	4.58	4.97	•	4.81
84	3.92	13.37	5.57	1.47	4.83	5.14	5.34	5.66	5.88
85	3.14	20.63	8.24	1.85	6.19	6.41	•	6.52	7.59
86	3.58	15.29	7.34	1.72	5.39	6.62	7.08	6.60	6.85
87	4.21	14.22	7.30	2.32	5.13	5.89	6.35	5.57	6.42
88	4.00	18.84	8.76	2.56	7.35	6.98	7.09	6.78	7.36
89	6.60	36.65	19.64	2.54	8.80	13.25	14.37	13.08	14.37
90	3.11	11.73	4.49	1.80	4.87	5.18	5.35	5.46	5.42
91	3.47	13.14	6.17	2.28	5.21	5.10	5.38	4.80	5.51
92	2.84	12.00	5.53	1.70	5.58	5.10	5.58	•	5.46
93	2.51	12.03	4.52	1.44	4.03	4.16	4.80	5.02	5.27
94	3.34	12.16	4.74	1.48	5.10	4.90	5.18	4.69	5.33
95	3.45	12.12	6.12	2.31	4.77	5.33	6.01	•	6.19
96	3.14	12.66	5.28	1.52	4.80	5.04	•	•	•

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
97	2.59	•	4.49	1.67	•	4.82	5.09	4.24	4.85
98	7.84	37.42	18.77	2.42	11.12	15.10	15.72	14.10	15.59
99	5.70	27.38	14.07	3.32	8.07	10.02	10.76	9.90	10.83
100	7.09	32.56	16.12	2.70	9.85	11.88	12.28	11.98	12.58
101	5.39	•	10.74	3.60	•	9.28	9.96	9.70	10.68
102	5.62	30.40	15.86	2.28	7.77	10.76	10.87	11.01	11.41
103	4.34	14.02	7.23	2.34	4.97	5.65	5.98	5.63	6.09
104	2.74	12.34	5.39	1.62	4.35	3.96	4.73	•	4.31
105	3.56	11.04	5.15	2.00	5.23	5.81	6.57	•	•
106	3.07	11.08	4.83	1.63	5.30	4.86	5.02	4.54	5.13
107	3.37	13.09	6.18	1.84	4.91	5.57	6.32	•	•
108	3.78	12.61	3.25	1.57	5.32	4.95	5.18	4.52	4.87
109	2.60	11.30	5.00	1.70	4.02	4.19	4.78	5.18	4.54
110	3.49	14.26	7.49	2.03	5.18	5.62	6.17	5.72	6.01
111	3.65	11.69	4.73	1.84	5.65	5.01	5.13	•	5.04
112	2.81	10.40	4.87	1.39	3.91	4.29	4.47	•	3.98
113	2.64	10.38	4.24	1.44	4.15	3.67	3.96	3.55	3.88
114	3.81	•	5.88	1.53	•	5.19	5.38	5.10	5.82
115	2.40	9.33	4.08	1.56	3.72	•	4.30	3.74	4.48
116	3.75	12.52	6.18	2.48	5.44	5.52	5.58	4.91	5.48
117	2.43	9.60	3.60	1.66	3.93	3.84	4.16	3.55	•
118	2.13	8.10	3.04	1.23	3.79	3.54	3.68	•	•
119	2.46	8.42	2.98	1.18	3.77	3.53	3.77	•	3.58
120	5.57	29.07	16.92	3.21	8.54	11.59	11.18	10.55	11.12
121	4.81	22.16	11.06	2.78	6.52	8.26	8.01	8.15	8.75
122	3.00	11.70	5.52	2.09	5.51	5.02	5.42	5.70	5.57
123	2.52	11.12	4.64	1.71	3.84	4.53	4.22	•	4.58
124	2.84	9.71	4.59	2.18	4.11	•	•	•	•
125	2.75	10.52	4.35	1.40	3.89	•	•	•	•
126	2.13	8.55	3.64	1.38	3.59	3.72	3.81	3.55	4.01
127	•	37.80	22.66	2.61	11.16	14.22	15.06	14.66	15.43
128	3.49	16.95	6.43	1.81	6.50	6.36	6.93	•	7.54
129	•	35.83	16.78	3.65	10.24	11.16	12.82	12.14	13.04
130	•	48.09	31.11	3.02	13.81	•	•	•	•
131	5.81	27.55	9.42	1.60	13.97	•	•	•	•
132	7.07	34.73	10.65	1.91	14.05	10.28	12.09	10.54	11.67
133	5.70	27.15	9.48	1.94	11.65	9.24	10.64	9.28	7.35
134	4.87	26.84	10.56	1.48	•	8.66	12.40	12.52	12.52
135	5.94	29.08	11.93	2.08	11.07	9.65	10.52	9.95	10.65
136	•	29.40	10.13	1.71	11.62	9.69	•	•	10.46
137	2.70	10.80	4.36	1.46	3.94	3.42	3.63	•	3.91
138	6.68	32.33	12.16	2.33	13.80	11.15	12.09	11.15	11.73
139	6.62	31.43	10.56	1.54	12.62	9.60	10.38	9.25	10.62
140	4.54	25.33	11.30	1.73	11.86	9.20	10.61	8.85	10.28
141	3.47	•	2.56	1.32	•	4.02	•	•	•
142	6.37	31.39	12.02	2.23	12.47	10.09	11.16	10.89	11.83
143	•	•	23.97	4.26	•	18.00	18.05	16.12	20.21
144	2.60	12.06	4.24	1.51	3.87	•	•	•	•

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
145	3.37	14.99	6.00	1.93	4.54	5.28	5.53	•	5.43
146	3.81	•	3.82	1.93	•	•	•	•	•
147	•	34.02	14.21	3.09	14.10	11.98	12.75	10.87	12.70
148	•	31.29	11.88	2.26	13.61	•	11.56	8.25	10.73
149	6.41	49.51	13.81	3.51	21.83	18.91	18.97	14.23	20.51
150	7.77	47.87	15.18	3.17	19.58	19.41	18.92	14.27	19.64
151	6.97	43.33	12.94	1.89	20.09	15.51	15.82	13.13	16.02
152	9.37	55.91	12.54	4.43	27.54	21.95	22.58	17.67	23.10
153	7.34	38.54	11.55	2.67	16.82	16.30	17.98	13.42	16.67
154	7.27	46.39	15.76	3.06	20.12	19.02	20.24	14.30	21.33
155	10.44	55.47	21.28	•	22.73	19.02	22.15	17.31	21.39
156	•	35.98	12.40	3.11	13.34	14.49	15.08	11.33	15.46
157	6.17	44.18	13.20	2.64	18.33	16.99	17.60	13.46	18.17
158	6.48	46.43	15.72	3.25	20.65	17.94	19.96	15.10	20.10
159	5.60	40.23	16.01	2.55	13.83	13.97	14.75	11.31	14.60
160	9.55	56.48	18.23	3.10	24.12	22.15	21.57	15.72	21.36
161	6.48	50.77	15.13	3.35	18.89	18.49	20.19	15.65	20.04
162	8.17	43.51	16.26	3.85	16.77	15.90	17.55	12.91	17.58
163	8.06	38.85	13.66	2.54	15.94	16.65	17.61	13.79	17.05
164	6.83	43.52	13.15	2.57	17.19	15.96	15.81	13.28	16.61
165	8.93	50.70	20.59	3.42	21.87	22.02	21.47	15.73	21.02
166	11.42	56.64	23.64	3.74	24.99	20.79	20.37	16.60	21.98
167	4.91	44.99	12.52	2.36	19.15	16.56	17.28	13.48	17.56
168	6.38	39.44	15.48	2.99	15.60	15.53	17.03	11.84	17.61
169	6.10	44.85	9.34	2.85	18.23	15.27	16.80	13.33	15.97
170	8.38	43.48	9.72	2.89	19.01	13.08	12.59	11.76	15.79
171	7.34	37.57	9.24	2.67	17.53	14.04	15.51	11.04	14.87
172	10.82	51.54	16.20	2.68	20.97	21.30	21.96	16.85	23.98
173	7.09	49.87	18.40	•	16.09	18.82	20.48	14.73	20.33
174	7.44	43.88	16.48	2.71	15.55	17.51	16.97	12.69	17.15
175	6.36	37.50	14.68	2.46	11.92	14.89	14.69	11.88	14.49
176	9.91	50.60	9.04	2.68	25.05	18.37	20.86	17.42	21.57
177	7.14	34.80	11.86	2.83	14.53	12.65	13.27	10.84	12.72
178	8.54	47.36	15.12	2.91	18.07	18.60	18.61	15.57	19.03
179	7.89	45.14	16.18	2.36	17.47	17.07	17.41	13.72	17.85
180	7.37	47.48	14.19	2.24	20.23	18.54	18.87	15.20	19.08
181	7.21	41.06	14.30	2.33	16.82	16.01	17.12	13.81	17.76
182	7.59	44.46	13.72	3.53	17.09	14.94	16.36	12.43	15.33
183	8.64	47.57	16.07	2.79	19.16	19.99	19.67	16.73	19.92
184	8.13	43.76	14.18	2.86	17.68	15.09	15.89	12.95	16.10
185	8.86	52.53	10.74	3.43	21.66	19.23	19.71	15.70	19.95
186	6.58	42.76	10.83	2.63	17.19	14.90	16.14	14.72	17.24
187	8.33	48.83	15.51	2.38	17.78	19.70	20.53	15.08	21.02
188	9.09	54.56	19.49	2.47	19.65	20.59	20.35	14.93	20.58
189	6.18	47.94	14.13	3.34	19.72	17.05	18.33	14.12	18.11
190	8.30	43.99	16.52	3.28	17.29	16.81	18.93	12.83	18.47
191	6.03	43.86	13.93	3.17	16.64	16.12	16.82	12.71	16.59
192	6.26	42.18	14.96	2.24	17.23	16.92	17.37	13.28	18.07

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
193	6.61	47.70	10.04	2.80	21.99	19.92	19.82	15.54	20.38
194	5.56	33.08	10.54	2.29	11.51	12.43	13.41	10.65	13.10
195	8.47	45.28	13.06	2.99	19.63	20.02	20.57	16.24	20.95
196	5.71	38.76	12.58	2.47	16.90	15.59	16.14	12.33	15.70
197	7.39	48.36	11.88	2.67	21.33	19.48	20.34	15.98	20.11
198	6.74	41.10	13.58	3.03	16.23	18.56	18.49	12.83	18.19
199	5.71	42.81	16.62	2.46	15.97	17.53	17.86	13.23	17.28
200	6.17	42.95	12.75	2.19	17.86	17.42	17.32	14.68	17.48
201	8.10	43.93	12.01	3.20	17.71	17.32	19.74	14.12	19.20
202	6.78	46.30	12.15	3.06	20.28	19.92	19.08	13.72	20.14
203	6.67	35.02	10.88	2.74	13.89	12.81	13.31	11.07	13.41
204	9.55	54.78	10.42	3.21	22.49	22.77	22.05	14.75	23.74
205	5.13	32.88	9.18	2.92	12.39	11.23	11.93	10.26	12.24
206	10.62	59.79	17.83	4.44	26.64	21.48	21.75	17.34	22.62
207	6.19	42.50	11.25	2.71	17.88	14.51	15.40	11.98	15.25
208	8.19	41.54	13.64	2.79	16.03	14.73	14.57	11.43	14.54
209	5.84	29.71	9.14	2.57	10.47	11.21	12.01	9.82	11.65
210	6.98	33.05	10.37	2.11	14.55	12.21	13.52	10.40	12.55
211	8.98	42.77	16.63	2.61	17.63	18.79	18.44	14.78	18.41
212	7.63	44.20	12.63	3.20	17.68	17.93	18.23	13.55	18.45
213	7.78	45.79	14.69	2.69	20.06	16.68	17.65	14.34	17.99
214	8.79	49.21	19.36	2.17	18.34	19.87	19.59	15.14	19.71
215	8.80	45.96	17.12	2.38	16.51	17.60	18.26	14.92	18.19
216	9.20	47.16	15.26	2.72	21.66	19.30	24.47	14.92	19.75
217	8.46	46.80	13.16	2.67	18.45	17.31	17.84	14.31	18.21
218	9.92	49.01	12.59	3.11	21.24	18.16	19.39	15.58	18.98
219	8.75	47.92	11.83	3.44	19.49	18.63	18.81	13.14	17.78
220	7.58	41.93	11.89	2.47	15.64	14.91	15.79	12.64	15.96
221	7.98	42.26	12.20	2.81	17.65	15.80	15.85	12.41	16.58
222	9.76	50.92	19.40	2.62	19.02	20.53	20.64	15.28	20.55
223	•	45.12	18.09	3.68	17.91	18.69	22.02	14.03	20.72
224	•	52.98	26.37	3.53	19.95	23.72	21.34	16.80	22.39
225	•	48.42	18.84	3.81	17.15	20.04	21.67	13.85	21.60
226	5.75	30.75	10.56	2.83	13.00	11.11	13.44	9.23	13.38
227	11.69	•	31.39	3.51	•	24.49	28.52	20.67	25.47
228	11.63	58.91	25.52	3.44	25.74	24.33	25.60	17.84	26.45
229	10.46	54.21	25.08	3.45	19.12	21.09	22.52	16.35	23.07
230	7.73	45.79	17.98	3.78	17.41	17.78	19.76	12.91	19.48
231	9.22	53.72	27.96	3.21	18.49	20.24	21.28	15.29	21.69
232	7.23	42.10	16.09	•	16.20	15.92	16.91	13.14	16.71
233	12.02	39.03	18.40	8.39	19.43	12.81	11.64	8.28	11.79
234	•	40.52	21.12	7.46	18.49	13.63	13.05	9.49	11.82
235	13.08	39.53	22.68	7.41	17.85	12.85	11.31	8.55	11.18
236	13.51	38.07	19.62	7.62	16.45	12.89	10.54	8.34	11.22
237	13.98	35.58	17.91	5.20	18.68	11.72	10.35	8.43	10.22
238	10.05	28.01	18.87	7.55	13.77	9.60	9.14	6.99	8.87
239	8.76	25.10	12.14	6.55	11.15	8.20	6.70	5.47	6.51
240	10.56	31.57	18.55	8.16	14.57	10.10	10.59	8.67	10.82

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
241	9.74	25.06	13.13	7.23	12.05	8.64	8.12	6.09	7.96
242	9.01	21.84	13.83	6.07	10.40	8.91	7.72	5.80	7.41
243	•	20.53	9.43	4.91	10.87	8.28	7.18	•	7.81
244	6.73	20.07	7.72	4.01	8.90	8.33	6.17	5.11	6.40
245	7.16	18.59	8.68	5.13	9.23	8.00	6.51	4.57	6.23
246	6.23	18.02	9.22	4.77	7.72	6.50	6.12	4.78	6.13
247	6.61	17.50	7.45	4.72	8.48	6.57	5.76	•	6.31
248	6.57	17.51	7.72	4.97	8.86	6.40	5.85	3.74	5.88
249	6.09	16.34	9.85	5.47	7.70	7.03	5.88	•	5.99
250	6.22	15.65	8.59	5.90	7.62	7.91	5.57	4.38	5.75
251	6.75	17.56	7.34	4.45	8.06	7.44	6.45	•	5.82
252	6.18	15.41	6.55	5.11	7.79	5.47	4.80	3.78	5.35
253	6.10	15.59	7.49	4.76	7.17	6.46	5.33	3.89	5.49
254	4.88	10.83	3.37	2.46	6.17	4.27	4.00	•	4.00
255	6.43	15.13	7.89	4.33	7.18	5.65	4.71	4.19	4.97
256	5.80	14.02	5.58	4.39	6.88	6.07	5.33	4.19	4.72
257	5.88	14.63	5.46	3.30	7.37	4.57	4.39	3.55	4.88
258	5.79	13.90	8.15	4.00	6.61	4.95	4.55	3.54	4.44
259	5.44	12.68	5.30	4.36	6.60	4.83	3.98	3.22	3.81
260	5.13	12.89	4.90	3.35	6.70	4.61	4.29	•	4.22
261	5.01	12.86	5.86	3.86	5.81	5.88	4.40	3.32	4.55
262	4.14	9.84	3.31	2.32	4.41	•	•	•	•
263	10.22	29.17	16.28	7.25	12.77	11.85	9.65	8.11	9.81
264	12.64	31.15	18.14	6.58	14.85	11.15	9.85	9.02	9.65
265	9.23	23.42	12.47	6.65	10.88	10.06	8.68	•	7.38
266	•	44.52	20.53	9.34	21.57	14.54	12.74	10.24	12.62
267	14.34	41.96	24.99	8.12	18.56	17.47	13.44	11.11	13.33
268	17.59	45.82	25.89	11.11	24.23	16.85	14.39	13.78	14.99
269	17.40	44.42	20.31	9.09	22.32	15.09	12.77	11.44	13.14
270	16.90	40.46	18.66	•	24.39	16.33	11.98	10.09	11.45
271	•	41.35	22.39	9.21	16.63	14.68	12.50	10.51	11.84
272	11.72	32.44	21.32	6.72	14.67	11.31	9.93	8.08	10.01
273	10.05	30.81	17.46	6.55	12.91	10.97	8.99	6.93	9.38
274	9.59	27.39	12.52	5.49	12.52	9.88	8.22	6.97	8.82
275	9.72	29.06	13.40	9.25	12.98	10.98	9.52	7.61	9.82
276	7.20	18.44	9.83	5.63	8.78	7.26	6.53	4.65	6.53
277	11.02	30.96	13.72	6.96	13.98	11.37	8.77	7.45	•
278	9.67	27.31	11.70	5.30	12.76	8.23	7.36	6.46	7.76
279	7.72	19.87	12.72	3.92	10.06	7.36	6.92	4.70	6.58
280	10.55	27.98	16.42	5.89	12.87	11.43	8.65	7.02	8.89
281	8.51	23.72	11.64	5.94	10.16	8.45	7.53	6.81	7.92
282	9.34	27.76	16.67	7.45	13.05	11.97	9.55	7.35	9.22
283	9.30	26.30	15.82	6.78	13.81	11.21	9.01	7.45	8.08
284	9.32	27.92	13.59	7.29	11.62	8.66	7.84	5.76	7.16
285	8.42	21.78	9.02	5.80	9.81	8.01	6.61	5.20	6.48
286	9.35	26.09	13.68	6.63	12.12	10.07	8.13	7.05	8.08
287	•	24.18	14.18	4.71	10.80	8.55	7.52	6.44	7.70
288	8.06	22.57	9.29	5.48	10.09	8.16	7.18	6.30	7.18

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
289	7.41	20.40	10.63	5.01	9.17	7.81	6.02	5.20	6.52
290	10.16	24.13	12.82	7.81	11.28	9.63	8.30	6.32	7.87
291	7.27	20.35	11.92	5.62	8.68	7.77	6.96	4.98	6.75
292	•	18.89	9.01	5.35	8.43	6.81	5.99	•	6.46
293	8.13	18.89	13.15	6.89	9.92	7.76	6.81	4.66	6.67
294	6.85	18.28	10.22	6.03	8.91	8.19	5.76	4.76	6.77
295	8.02	22.62	9.95	6.31	10.31	9.19	7.45	6.13	7.05
296	8.03	20.60	8.21	5.02	9.04	7.01	6.06	5.12	5.81
297	6.41	18.36	6.84	4.74	7.65	6.11	5.18	•	5.86
298	7.59	19.33	7.98	5.89	9.29	8.06	6.50	4.66	6.42
299	7.09	19.18	10.10	5.44	8.63	7.57	7.24	6.03	7.18
300	6.22	16.95	7.52	4.74	7.42	6.72	5.96	5.17	5.83
301	6.45	16.84	7.65	4.60	8.54	7.13	5.15	4.62	5.38
302	6.09	15.79	7.79	4.54	7.03	6.28	5.33	4.02	5.54
303	5.86	16.59	9.31	5.09	7.33	6.47	5.63	4.10	5.56
304	5.93	14.17	5.96	3.65	7.33	6.33	4.57	3.77	4.49
305	5.68	15.15	8.05	4.67	6.65	6.43	5.62	3.98	5.36
306	5.84	14.95	6.52	4.35	7.40	5.15	4.52	3.18	4.31
307	5.28	15.56	5.55	3.03	7.74	5.96	5.07	•	5.14
308	6.02	15.01	7.04	4.01	7.02	5.96	5.07	4.29	5.49
309	5.90	17.08	6.79	5.27	9.22	7.07	5.81	4.32	5.59
310	5.82	16.05	9.12	5.15	7.56	7.52	6.06	4.69	6.06
311	5.78	15.29	7.69	5.14	6.75	5.64	4.65	3.63	4.66
312	6.17	16.38	8.92	4.76	7.15	7.64	5.21	4.24	5.67
313	6.72	17.99	8.25	4.40	8.30	5.86	5.46	4.90	5.70
314	6.78	19.35	9.75	5.14	9.00	7.47	6.79	4.84	6.72
315	5.33	13.86	6.75	3.78	6.48	6.64	4.87	3.77	4.68
316	5.59	14.14	6.78	4.72	6.84	4.81	4.46	3.50	4.30
317	6.69	16.64	8.73	5.42	7.04	6.74	5.46	5.45	6.64
318	5.37	14.29	7.24	3.98	6.67	5.95	4.30	2.84	4.62
319	5.36	13.14	6.78	4.20	6.77	5.45	4.73	3.87	4.52
320	5.07	13.64	6.52	4.29	6.28	4.85	4.57	3.18	4.38
321	5.22	12.69	6.14	3.30	6.71	5.25	3.98	•	4.53
322	6.43	15.86	6.50	4.35	7.91	5.40	4.51	3.91	4.94
323	5.05	12.03	4.76	2.97	6.40	5.17	4.52	•	6.02
324	5.51	12.95	5.62	3.47	6.64	5.50	3.97	3.44	4.19
325	4.68	11.36	4.64	3.24	5.41	4.05	3.69	2.70	3.72
326	4.69	10.22	4.46	3.46	5.17	4.26	3.52	•	3.38
327	3.95	10.68	5.01	3.20	4.60	4.40	4.05	2.96	3.84
328	4.11	10.21	3.96	2.78	5.41	4.06	3.50	2.60	3.29
329	4.54	10.03	4.17	2.54	4.96	3.32	2.89	•	•
330	3.82	9.03	3.93	2.97	4.99	3.33	3.21	•	3.01
331	3.70	9.78	3.48	2.46	4.64	3.55	3.29	•	3.15
332	3.68	9.25	3.68	2.62	4.57	•	•	•	•
333	4.23	8.93	3.09	2.28	4.63	•	•	•	•
334	15.19	41.58	24.43	7.17	19.02	14.99	13.96	9.22	12.39
335	11.48	30.26	16.87	8.39	14.66	10.10	9.16	6.30	8.22
336	9.52	24.43	13.47	7.09	12.52	11.47	8.63	6.67	8.92

#	PPP	POSAP	ANLL	ANLW	ANLP	PDI	PDII	PDIII	PDIV
337	8.86	24.07	13.55	6.72	10.76	8.93	7.78	5.58	8.03
338	7.90	21.75	12.36	6.34	9.62	8.86	7.56	7.27	8.02
339	8.94	20.46	12.29	6.47	9.70	8.97	7.29	5.14	6.90
340	8.13	21.76	9.56	5.62	9.86	7.79	6.82	4.51	6.78
341	7.39	20.29	9.52	5.18	9.13	7.82	6.99	6.19	6.44
342	5.80	19.43	9.95	4.33	8.43	8.53	6.72	5.92	6.14
343	6.37	18.23	9.16	5.46	9.32	8.40	6.48	5.38	6.43
344	7.43	18.69	8.96	5.01	8.17	6.92	6.52	•	5.46
345	6.76	17.22	7.54	4.55	8.42	6.82	5.86	4.60	5.95
346	6.40	16.52	7.08	3.96	7.78	5.92	5.50	4.25	4.98
347	5.89	14.58	7.29	4.48	6.56	5.49	4.78	3.86	4.97
348	5.09	12.13	4.94	3.38	5.95	5.04	4.65	•	4.53
349	4.69	11.54	4.51	3.29	5.79	4.48	3.29	•	3.44
350	4.71	11.38	3.17	2.46	6.15	4.32	3.43	2.91	3.37
351	4.19	10.71	3.97	2.62	5.33	3.16	3.55	3.37	3.82
352	4.16	9.66	3.29	2.81	4.63	3.10	2.77	2.37	3.22
353	3.64	7.49	2.72	2.23	3.92	•	•	•	•
354	7.63	33.29	7.97	2.84	13.89	•	•	•	12.77
355	•	•	•	1.73	•	•	14.77	12.77	12.56
356	•	•	•	•	•	16.14	14.43	14.38	•
357	•	•	18.50	6.24	•	•	•	•	•
358	•	•	15.40	7.45	19.12	•	•	•	•
359	•	•	12.12	5.35	•	14.37	16.49	14.37	16.35
360	•	•	12.96	5.57	•	•	•	•	•
361	•	41.74	18.83	6.64	19.86	•	•	•	•
362	6.05	32.41	7.63	3.37	14.89	12.14	12.42	10.17	12.21
363	•	29.93	8.52	3.86	14.36	10.33	•	•	•
364	14.24	30.75	21.31	11.89	16.31	•	•	•	•
365	•	26.35	15.25	11.13	16.39	7.02	•	•	6.98
366	6.31	11.65	7.22	5.99	7.68	•	•	•	•
367	5.47	11.51	6.56	5.21	6.21	•	•	•	•
368	•	11.58	6.55	5.47	5.68	•	•	•	•
369	5.25	10.92	5.54	5.52	5.67	•	•	•	•
370	13.43	33.47	22.77	13.81	21.46	9.30	9.28	6.56	9.25
371	•	44.89	12.24	2.29	20.30	14.13	13.98	13.57	16.97
372	•	•	32.94	1.84	•	22.41	21.83	22.31	25.90

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
1	13.56	76.27	1.93	6.33	7.31	5.75	1.62	1.87	5.27
2	8.08	45.87	1.51	3.41	5.02	3.53	1.43	1.46	3.09
3	7.13	34.41	1.19	2.76	3.81	2.75	1.21	1.04	2.23
4	6.01	32.82	1.49	2.71	3.45	2.52	1.13	1.06	2.19
5	5.52	27.81	1.02	2.24	3.23	1.70	0.90	1.00	1.84
6	•	21.97	1.04	1.86	2.46	1.68	0.87	0.87	1.53
7	12.59	73.27	1.79	5.58	6.80	4.99	1.54	1.65	4.87
8	7.17	45.65	1.27	3.18	4.49	2.92	1.24	1.16	2.80
9	6.38	43.05	1.27	3.30	3.91	3.11	1.27	1.20	2.69
10	8.39	45.46	1.85	3.75	5.15	3.12	1.60	1.42	3.08
11	6.57	40.28	1.24	3.08	4.52	2.81	1.16	1.23	2.46
12	6.75	35.10	1.24	2.87	3.86	2.83	0.96	1.02	2.54
13	6.55	31.39	1.05	2.75	3.65	2.13	1.23	1.19	2.23
14	5.58	28.90	0.63	2.15	3.27	2.13	0.81	0.99	1.67
15	•	21.45	0.91	1.81	•	1.85	0.91	0.91	1.66
16	•	•	1.34	2.33	3.50	2.87	1.15	•	2.23
17	13.06	73.92	2.29	5.86	7.82	7.04	1.73	1.87	5.47
18	10.71	64.73	1.60	4.77	6.31	5.00	1.48	1.47	4.21
19	11.25	62.92	1.72	4.35	6.23	4.72	1.53	1.42	3.45
20	13.53	76.07	2.08	6.24	8.03	6.19	1.77	1.66	5.18
21	6.29	38.15	0.83	2.76	3.81	2.45	1.09	1.05	1.98
22	5.29	27.78	1.11	2.36	3.51	2.15	1.13	1.11	1.90
23	6.62	35.15	1.46	2.92	3.88	2.59	1.25	1.38	2.41
24	6.73	34.59	1.14	2.83	3.82	2.33	1.04	0.88	2.19
25	6.37	•	1.07	2.95	3.72	2.95	1.02	1.05	2.42
26	•	•	1.04	2.27	3.83	2.22	0.96	•	2.09
27	6.35	33.87	0.80	2.51	3.32	2.24	•	0.95	2.00
28	10.51	57.41	1.54	3.75	5.94	4.61	1.51	1.27	3.39
29	7.34	40.65	1.37	3.22	4.59	2.98	1.19	1.25	2.65
30	•	•	0.62	2.47	3.30	2.29	1.13	1.23	2.15
31	•	29.69	0.80	1.91	2.76	•	•	0.96	1.72
32	4.99	24.19	0.96	2.03	2.81	1.63	0.95	0.86	1.63
33	4.01	20.21	0.63	1.46	2.08	1.49	0.87	0.81	1.24
34	4.03	19.30	0.81	1.75	2.23	1.46	0.95	0.92	1.40
35	10.87	64.02	1.67	4.96	6.79	5.48	1.68	1.39	4.31
36	10.23	58.72	1.52	4.40	5.70	4.83	0.99	1.32	3.73
37	11.15	66.54	1.66	5.14	6.52	5.35	1.09	1.57	4.33
38	6.43	34.93	0.73	2.47	3.32	2.37	0.86	1.02	2.17
39	6.24	33.12	1.25	2.61	3.86	2.45	1.11	1.18	2.09
40	•	30.45	0.88	2.61	3.59	2.59	1.15	0.97	2.31
41	5.23	30.79	0.74	2.19	2.99	2.12	0.87	0.95	1.86
42	5.38	29.48	1.19	2.46	•	2.43	0.92	1.10	2.12
43	6.76	28.72	0.96	2.26	3.50	1.96	0.71	0.85	1.68
44	5.46	27.15	1.33	2.13	3.23	2.14	0.96	0.99	1.77
45	4.48	21.75	0.82	2.19	2.93	1.91	0.93	0.97	1.72
46	12.59	77.29	2.22	5.44	•	5.77	1.43	1.63	4.83
47	5.81	31.19	0.93	2.37	3.60	2.38	1.02	1.04	1.90
48	5.16	25.55	1.01	2.14	3.06	1.84	1.02	0.88	1.76

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
49	4.74	26.49	0.69	1.71	2.38	1.62	0.74	0.82	1.38
50	4.77	26.21	0.88	2.04	2.75	2.03	0.95	0.95	1.71
51	3.93	22.96	0.83	1.79	2.37	1.90	0.72	0.77	1.75
52	•	23.92	0.66	2.05	2.51	1.87	1.01	0.85	1.82
53	•	19.43	0.97	1.75	2.43	1.85	0.85	0.85	1.60
54	•	•	0.71	1.77	2.24	1.81	0.83	0.86	1.46
55	•	18.77	0.77	1.56	2.09	1.43	0.72	0.64	1.32
56	•	17.65	0.66	1.53	2.10	1.48	0.67	0.64	1.15
57	•	14.85	0.64	0.96	1.67	1.10	0.69	0.72	0.92
58	8.63	42.51	1.46	3.25	5.02	3.43	1.46	1.46	2.86
59	9.16	42.51	1.35	2.76	4.23	3.03	1.21	1.34	2.15
60	•	58.36	1.74	3.98	6.18	4.07	1.81	1.71	3.48
61	7.27	39.24	1.55	3.32	4.54	3.25	1.32	1.27	2.65
62	6.21	33.15	0.73	2.82	•	2.53	1.33	1.12	2.17
63	7.63	45.46	1.30	3.38	4.63	3.40	1.37	1.35	2.71
64	7.08	33.27	1.46	2.68	4.05	2.83	1.25	1.32	2.23
65	6.90	34.79	1.07	2.54	3.89	2.61	1.25	1.18	2.07
66	13.67	77.06	2.29	5.95	7.09	5.79	1.85	2.01	5.15
67	7.67	35.54	0.99	2.79	3.63	2.92	1.09	1.15	2.58
68	7.67	42.62	1.73	3.70	•	3.72	1.58	1.50	2.90
69	10.07	54.85	1.56	4.83	5.94	4.06	1.54	1.59	3.57
70	•	34.56	1.27	3.40	3.80	2.79	1.15	1.30	2.74
71	7.18	39.95	1.49	3.41	4.77	3.34	1.57	1.34	2.63
72	6.88	33.61	1.17	2.58	3.23	2.19	1.26	1.19	2.07
73	•	62.81	1.89	•	•	•	•	1.65	4.23
74	7.28	37.94	1.29	3.17	4.11	2.93	1.28	1.44	2.52
75	5.81	37.99	0.98	2.54	3.11	2.54	1.09	1.19	2.35
76	7.41	42.08	1.67	3.78	4.60	3.59	1.63	•	•
77	13.91	80.51	2.25	5.61	•	•	1.63	1.84	5.47
78	•	28.34	0.85	2.18	2.89	1.89	0.95	0.91	1.70
79	5.95	31.10	0.96	2.52	3.52	2.54	1.30	1.24	2.10
80	5.48	28.48	0.70	2.74	3.26	2.05	1.01	1.22	2.08
81	4.76	26.68	1.15	2.01	2.58	1.85	1.03	1.01	1.55
82	4.96	28.66	1.03	2.26	3.14	2.14	1.20	0.98	1.88
83	5.32	25.13	0.76	1.87	•	1.69	1.11	0.90	1.49
84	5.72	29.37	1.09	2.59	3.52	2.36	1.22	1.25	2.07
85	6.78	•	1.24	2.44	3.99	2.71	1.09	•	•
86	6.50	•	1.44	2.89	3.54	2.72	1.23	•	•
87	6.22	31.90	1.12	2.52	3.78	2.58	1.23	1.18	2.06
88	7.08	42.41	1.08	3.66	4.73	3.37	1.29	1.56	2.96
89	13.57	79.37	2.36	5.74	7.85	6.59	1.57	1.86	5.04
90	5.39	26.74	0.73	2.49	3.27	2.19	1.01	•	•
91	5.13	29.69	1.27	2.49	3.28	2.20	1.08	1.22	1.66
92	5.25	28.21	0.84	1.97	2.91	2.10	1.06	1.17	1.75
93	4.44	27.21	0.97	1.88	2.35	1.58	0.82	0.93	1.42
94	5.15	27.33	0.81	2.10	2.97	2.12	1.22	1.08	1.60
95	5.28	26.82	1.08	2.51	3.10	2.12	1.12	1.06	1.99
96	5.48	28.18	0.78	2.18	2.98	2.25	1.25	1.17	1.76

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
97	4.74	26.60	1.09	2.18	2.92	2.06	1.10	1.07	1.74
98	14.24	79.51	2.49	6.39	8.30	7.33	1.83	1.87	5.56
99	10.74	60.12	1.99	4.42	6.26	5.23	1.45	1.61	3.96
100	12.20	71.75	2.10	5.23	7.18	5.82	1.64	1.68	4.77
101	10.19	55.95	1.68	3.77	•	4.16	1.49	1.50	3.47
102	10.78	63.46	1.91	3.93	5.92	4.59	1.32	1.35	3.33
103	5.71	30.78	1.11	2.53	3.41	2.58	1.13	1.10	1.99
104	•	26.47	0.97	2.09	2.58	2.12	0.94	0.91	1.71
105	6.10	27.59	0.79	2.67	3.43	2.25	1.07	0.92	1.98
106	4.83	27.62	1.09	2.28	3.07	2.07	1.25	1.12	1.74
107	5.79	30.27	0.88	2.36	3.28	2.36	1.24	1.15	1.99
108	4.91	27.77	1.19	2.51	3.05	2.04	1.43	1.17	2.16
109	4.45	25.97	0.94	2.24	2.75	2.09	0.94	1.01	1.71
110	5.74	31.05	1.26	2.48	3.63	2.36	1.25	1.33	2.14
111	5.11	27.91	0.89	2.49	3.06	2.12	1.25	1.20	1.97
112	4.27	22.39	0.76	1.76	2.63	1.59	0.96	0.95	1.46
113	3.68	23.31	1.08	1.90	2.52	1.99	0.89	0.90	1.71
114	5.38	29.85	1.26	2.56	3.37	2.26	1.25	1.27	2.09
115	•	21.76	0.94	2.04	2.46	1.93	1.06	0.93	1.67
116	4.82	28.98	1.09	2.23	3.22	2.35	1.24	1.08	1.78
117	•	20.85	0.99	1.73	2.30	1.50	0.85	0.91	1.29
118	3.36	18.55	1.05	1.51	2.13	1.58	0.98	0.85	1.42
119	3.14	18.14	0.88	1.84	2.18	1.67	0.91	0.88	1.49
120	11.82	66.57	1.95	4.83	6.98	5.35	1.60	1.80	4.47
121	8.31	49.03	1.72	3.82	5.15	4.06	1.20	1.42	3.14
122	5.16	28.35	•	2.40	3.06	2.36	1.10	1.22	2.17
123	•	25.51	0.80	2.06	2.52	2.05	1.06	1.08	1.76
124	•	22.97	1.01	2.26	2.76	2.12	1.30	1.10	1.84
125	•	23.32	0.79	2.07	2.70	1.99	1.07	0.95	1.67
126	3.83	19.49	1.02	1.73	2.28	1.65	0.93	0.90	1.50
127	14.21	84.84	2.31	5.83	•	6.95	1.64	1.78	4.97
128	•	38.15	0.73	3.45	3.98	3.23	1.26	1.26	2.99
129	11.64	77.80	2.37	6.13	7.78	6.37	1.67	1.88	4.97
130	•	105.95	2.60	7.91	•	8.08	•	2.28	6.27
131	•	60.32	2.17	6.57	7.89	5.74	1.06	1.70	6.08
132	11.02	70.48	3.84	8.22	9.08	6.97	2.08	3.18	7.56
133	10.21	•	1.82	7.16	8.45	6.15	2.08	2.61	6.09
134	12.83	•	1.58	3.96	5.19	2.99	•	1.11	3.96
135	10.97	59.24	3.16	6.17	8.20	6.29	2.12	2.43	5.28
136	9.98	•	2.33	5.80	•	5.48	1.56	2.04	5.43
137	3.68	22.96	0.83	2.04	2.56	1.89	1.04	0.99	1.72
138	10.49	69.29	3.12	6.36	8.17	6.32	1.87	2.29	5.48
139	9.27	64.69	3.02	5.66	7.40	5.47	1.43	1.79	5.29
140	9.51	56.10	2.59	5.84	7.08	5.46	1.71	1.90	5.14
141	•	21.18	1.47	2.04	2.76	1.94	0.99	1.14	2.13
142	10.87	65.68	3.32	6.87	8.48	6.05	2.20	2.59	6.07
143	16.17	129.33	3.04	•	•	8.86	1.89	2.29	7.02
144	•	25.71	1.02	2.05	2.64	2.10	1.10	1.01	1.79

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
145	5.54	31.71	1.02	2.94	3.34	2.69	1.14	1.18	2.41
146	•	30.39	1.47	•	•	2.60	1.04	1.27	•
147	12.14	73.10	2.97	8.39	10.56	8.16	2.56	3.25	8.00
148	•	65.60	2.87	6.42	8.35	6.36	1.95	2.23	6.27
149	18.07	114.60	1.18	8.48	•	8.02	1.28	1.53	5.82
150	19.73	104.03	1.82	6.99	•	5.18	0.92	1.29	5.20
151	15.59	98.62	1.79	6.79	•	5.86	1.09	1.38	4.25
152	21.68	122.01	2.59	8.50	•	9.54	1.24	1.61	6.30
153	16.28	85.21	1.83	6.32	•	5.32	1.01	1.33	4.10
154	18.88	104.59	2.00	8.01	•	6.50	1.23	1.38	5.49
155	19.40	120.76	2.01	10.50	•	9.07	1.50	1.64	7.30
156	13.84	76.39	1.57	5.55	7.77	4.98	1.04	•	3.82
157	17.17	•	1.47	6.08	9.01	5.20	1.21	1.18	4.31
158	18.08	107.46	1.54	7.60	•	5.72	0.96	1.24	5.14
159	13.91	89.78	1.32	5.32	•	5.35	0.90	1.21	4.24
160	21.55	120.27	2.52	9.09	•	9.33	1.26	1.56	6.43
161	19.32	113.15	1.57	7.08	•	6.38	1.06	1.16	5.33
162	16.76	96.58	1.94	6.26	•	6.06	1.15	1.54	4.67
163	16.02	87.30	1.80	6.22	•	5.21	1.12	1.15	4.22
164	16.11	93.85	1.10	5.61	•	6.21	1.10	1.23	4.26
165	21.32	116.36	2.70	10.22	•	8.59	1.22	1.65	6.99
166	20.08	•	2.28	10.45	•	8.90	1.46	•	•
167	16.24	96.93	1.27	6.78	•	5.99	0.88	1.14	4.29
168	16.73	•	1.47	6.74	9.55	4.97	0.96	0.91	4.81
169	16.40	91.70	1.32	5.25	•	4.57	1.01	1.06	3.73
170	15.10	•	1.65	6.23	•	•	•	1.31	5.61
171	13.87	84.39	1.59	5.82	8.66	5.71	1.18	1.28	4.09
172	21.57	119.74	2.38	8.42	•	7.57	1.27	1.72	6.08
173	19.38	111.84	1.98	8.48	•	6.35	1.27	1.53	6.15
174	17.45	93.93	1.65	•	•	•	•	1.08	5.23
175	14.64	79.69	1.27	5.09	8.58	4.38	0.96	1.05	3.58
176	19.39	114.95	1.84	7.83	•	8.31	1.39	1.44	6.91
177	13.07	76.64	1.56	5.94	8.96	5.55	1.18	1.19	4.44
178	17.34	•	•	6.98	10.36	6.71	0.96	•	•
179	17.30	102.70	1.73	7.57	•	7.37	0.97	1.20	5.61
180	19.11	108.39	1.63	7.03	•	5.41	0.93	1.23	4.78
181	17.34	87.34	1.58	6.02	9.40	6.28	1.04	•	•
182	16.21	95.72	1.54	5.95	•	5.75	1.13	1.47	4.86
183	19.89	104.85	1.63	6.67	•	6.24	1.05	1.31	5.07
184	15.80	94.16	1.95	6.01	•	6.81	1.06	1.23	4.52
185	18.79	116.52	2.13	8.79	•	7.86	1.16	1.48	6.72
186	15.55	88.77	1.84	6.18	•	4.87	0.98	1.30	3.89
187	20.07	104.53	2.19	7.97	•	7.74	1.08	1.44	5.91
188	20.17	116.69	2.59	9.42	•	8.87	1.31	1.64	6.80
189	17.74	104.91	1.60	6.84	•	6.69	1.09	1.35	4.96
190	16.75	102.06	2.02	7.38	•	7.05	1.19	1.46	5.30
191	16.11	98.66	1.71	6.19	•	5.43	0.95	1.04	4.45
192	16.67	91.46	1.46	5.66	•	6.19	0.97	1.09	3.86

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
193	19.77	105.46	1.81	7.12	•	6.85	0.87	1.40	5.28
194	12.45	69.88	1.11	4.16	7.23	4.57	0.78	0.96	3.55
195	20.03	102.17	2.18	7.50	•	6.10	1.09	1.27	5.37
196	15.34	85.05	1.63	6.18	•	5.54	0.90	1.01	4.02
197	19.36	107.28	1.27	7.01	•	5.88	1.11	1.19	5.08
198	18.02	95.96	1.43	5.79	•	5.37	0.99	1.11	4.24
199	17.09	97.14	1.68	7.72	•	5.58	1.00	1.30	5.08
200	16.85	98.48	1.57	6.60	•	6.10	1.01	1.10	4.53
201	17.38	95.91	2.01	6.23	•	5.89	1.16	1.38	4.51
202	19.74	105.86	1.67	6.47	•	6.70	1.01	1.29	4.78
203	12.52	74.94	1.80	5.38	7.54	4.72	1.10	1.26	3.95
204	23.27	125.67	1.93	8.01	•	6.84	1.21	1.32	5.72
205	11.74	69.55	1.09	4.12	6.89	3.97	0.90	1.23	3.21
206	22.42	135.33	2.94	10.69	•	9.56	1.44	1.78	8.55
207	14.45	92.84	1.28	6.12	•	4.80	0.96	0.96	3.87
208	15.64	91.01	1.86	7.04	8.97	5.26	1.24	1.42	4.50
209	11.26	•	1.29	3.95	5.88	3.58	0.88	0.93	2.49
210	12.18	74.21	1.29	5.08	7.67	4.80	0.88	1.09	3.72
211	17.66	98.35	1.84	6.15	•	5.67	0.97	1.21	4.05
212	17.82	93.73	1.73	6.42	•	6.14	0.98	1.22	4.97
213	16.47	105.82	1.92	7.49	•	6.17	1.10	1.31	5.55
214	19.47	105.02	2.42	7.73	•	7.27	1.18	1.56	5.98
215	17.25	97.74	1.85	7.83	•	6.86	1.02	1.18	5.78
216	18.64	107.14	1.97	•	•	•	•	1.35	4.99
217	17.73	105.70	1.63	7.55	•	5.73	0.99	1.37	4.79
218	20.39	107.91	1.74	7.85	•	8.42	1.30	1.38	5.86
219	17.25	104.02	1.88	8.46	•	7.65	1.25	1.35	6.35
220	15.14	92.31	1.51	6.35	•	5.27	1.09	1.33	4.61
221	15.60	94.96	1.60	6.73	•	6.22	0.98	1.17	4.83
222	20.53	118.24	1.93	9.15	•	7.34	1.05	1.53	6.44
223	19.34	106.73	2.73	10.80	•	7.63	1.21	1.51	6.73
224	24.33	137.94	2.31	11.37	•	8.55	1.53	1.87	7.12
225	21.92	109.93	2.84	10.31	•	7.87	1.51	1.61	7.48
226	11.96	72.36	2.12	7.82	•	6.32	1.30	1.48	5.85
227	24.84	•	2.85	11.82	•	10.21	2.04	2.31	8.14
228	26.73	140.53	•	11.04	•	9.39	1.79	2.01	8.63
229	21.65	129.38	2.89	10.66	•	8.63	1.86	1.94	8.00
230	18.05	107.89	2.08	10.64	•	6.87	1.10	1.54	6.90
231	21.46	132.63	2.52	11.58	•	7.51	1.47	2.15	6.78
232	15.97	96.38	2.23	8.53	•	6.50	1.16	1.42	6.40
233	13.39	86.85	3.23	6.31	8.44	6.73	3.06	3.16	5.57
234	13.30	93.89	4.06	7.18	•	6.71	2.47	3.00	6.59
235	13.41	88.16	3.72	6.31	9.20	6.59	2.99	3.03	6.08
236	12.54	83.09	3.94	8.11	10.73	7.59	3.83	3.39	7.27
237	11.35	79.64	4.02	5.81	7.77	6.69	3.03	2.76	5.44
238	10.38	66.99	3.59	6.23	7.98	6.93	2.62	2.71	5.66
239	8.63	56.64	3.54	5.70	7.63	6.55	3.12	3.23	5.67
240	10.92	72.54	3.92	5.48	7.62	7.16	2.94	3.20	5.61

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
241	8.68	57.41	3.03	4.92	6.89	5.96	2.15	2.59	4.57
242	8.86	49.53	2.81	4.39	5.81	4.82	2.51	2.42	4.12
243	7.74	46.22	2.48	4.24	5.86	5.46	2.26	1.99	4.12
244	8.08	42.87	2.90	4.35	6.13	5.20	2.19	2.08	4.20
245	7.35	40.94	2.69	3.86	5.89	5.28	1.84	2.15	4.29
246	6.75	40.38	2.07	3.79	4.95	4.25	1.61	1.79	3.46
247	7.22	38.32	3.02	4.29	5.48	4.72	2.10	2.38	4.27
248	6.64	37.38	2.71	4.02	5.34	4.83	1.91	2.36	4.08
249	7.54	36.91	1.98	3.51	4.74	3.60	1.70	1.56	3.37
250	6.94	37.90	2.28	3.49	4.44	3.81	1.85	1.99	3.20
251	7.20	36.52	2.04	3.91	5.28	4.57	1.93	1.93	3.79
252	5.57	33.99	2.05	3.65	4.72	3.64	1.85	2.05	3.40
253	6.18	34.74	2.05	3.09	4.19	3.65	1.72	1.66	3.04
254	3.93	25.05	1.63	2.59	3.32	2.51	1.20	1.46	2.13
255	5.68	34.50	2.38	3.59	4.74	3.82	1.90	1.82	3.65
256	6.23	31.11	2.22	3.12	4.21	3.14	1.57	2.03	3.17
257	5.23	31.10	2.13	3.42	4.26	3.58	1.65	1.95	3.27
258	5.52	29.99	1.98	3.25	3.98	3.20	1.62	1.95	3.06
259	5.10	29.01	1.79	2.76	3.81	3.09	1.66	1.86	2.61
260	5.05	28.53	1.72	2.60	3.34	2.75	1.86	1.54	2.38
261	5.29	27.20	1.57	2.59	3.59	2.67	1.35	1.32	2.42
262	•	20.82	1.19	2.15	2.88	2.37	1.40	1.43	2.09
263	13.74	68.39	4.69	6.45	9.97	7.74	3.71	3.89	6.22
264	10.85	70.46	5.11	6.75	9.08	8.93	3.46	3.89	6.56
265	8.92	52.42	4.15	5.06	6.41	5.79	3.16	3.29	5.29
266	14.51	99.50	5.76	8.87	•	11.45	3.43	3.86	9.42
267	16.79	96.63	5.57	7.87	•	11.83	4.11	4.37	8.09
268	16.72	107.51	4.92	8.55	•	12.47	4.03	4.04	8.11
269	15.86	101.05	4.59	7.75	•	9.91	3.64	4.01	7.19
270	16.43	99.83	5.49	8.83	•	10.54	4.12	•	•
271	17.03	94.32	5.64	7.62	•	10.33	3.61	4.23	7.88
272	11.65	71.78	4.43	6.94	9.39	8.55	4.43	3.43	6.91
273	12.08	64.71	4.53	6.09	7.41	6.65	2.85	3.74	5.83
274	9.91	62.10	4.78	5.88	7.37	9.61	4.19	3.96	6.37
275	12.35	65.07	5.14	6.69	9.07	9.47	3.69	3.96	6.61
276	7.03	42.41	3.51	4.33	5.66	5.44	2.55	2.62	4.07
277	11.17	67.68	5.08	6.73	8.57	9.55	3.59	3.84	6.23
278	9.17	60.73	4.44	6.34	8.13	8.13	3.59	3.47	6.01
279	7.61	43.66	3.75	4.70	5.83	6.14	2.93	3.05	4.69
280	11.15	65.41	3.90	5.85	7.93	7.46	3.08	3.04	5.18
281	8.64	54.18	3.74	4.84	6.17	5.25	2.98	2.89	4.64
282	11.08	66.38	4.35	5.63	7.83	7.18	2.75	3.26	5.56
283	11.51	65.25	4.02	5.48	7.56	6.98	2.91	3.03	4.83
284	8.81	61.01	4.48	5.63	7.51	7.15	3.83	3.38	5.34
285	8.72	45.35	3.78	4.80	6.12	5.62	2.75	3.13	4.84
286	10.85	64.12	3.69	5.19	6.99	6.91	2.76	3.14	4.62
287	8.33	51.38	3.75	5.42	6.94	6.89	2.76	2.99	4.79
288	8.66	48.16	3.74	4.84	6.19	5.78	2.71	2.84	4.69

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
289	8.23	46.21	3.76	4.56	5.63	5.08	2.48	2.68	3.98
290	9.16	57.69	4.31	5.70	7.24	5.96	3.11	3.35	5.22
291	7.56	47.24	3.73	4.66	6.29	5.20	2.67	3.15	4.61
292	8.03	41.48	3.46	4.35	5.67	5.60	2.82	2.94	4.31
293	8.54	44.54	3.26	4.93	5.98	5.65	2.75	2.95	4.84
294	8.15	42.02	3.27	3.93	5.35	5.32	2.87	2.71	4.08
295	9.02	50.62	3.56	4.64	6.05	5.84	2.90	2.97	4.27
296	6.90	43.50	3.09	4.22	5.69	4.89	2.74	2.48	4.28
297	7.12	39.29	3.62	4.49	5.61	5.18	2.81	2.98	4.27
298	8.04	42.24	2.96	4.30	5.33	5.45	2.77	2.52	4.01
299	7.44	43.89	3.60	4.49	5.55	5.68	3.04	2.87	4.49
300	6.57	38.10	3.11	3.70	4.73	4.22	2.38	2.51	3.51
301	6.90	38.99	3.01	3.86	4.94	4.57	2.55	2.84	3.92
302	7.14	36.36	3.32	3.85	4.94	4.36	2.41	2.75	3.64
303	6.57	37.42	3.06	3.84	5.23	4.50	2.57	2.60	3.56
304	5.68	31.24	2.60	3.26	4.27	3.78	1.99	1.97	2.99
305	7.40	34.73	2.73	3.52	4.43	3.67	2.20	2.17	3.21
306	5.65	32.04	2.65	3.31	4.35	3.84	2.24	2.21	3.30
307	5.85	36.06	2.35	2.52	3.55	2.73	1.44	1.72	2.38
308	6.70	33.52	2.37	2.99	4.27	3.66	1.94	2.04	2.79
309	7.39	37.41	3.34	4.11	5.39	4.48	2.62	2.55	3.98
310	7.03	35.55	2.84	3.54	4.52	3.90	2.19	2.29	3.39
311	5.37	35.21	2.54	3.47	4.62	3.87	2.07	2.12	3.18
312	7.78	38.16	3.02	3.75	4.81	4.02	2.30	2.41	3.49
313	7.11	38.56	2.92	3.73	4.61	2.25	2.38	2.41	3.54
314	7.96	43.28	3.45	4.15	5.23	4.90	2.61	2.76	4.21
315	6.90	30.73	2.17	2.94	4.13	3.60	2.07	1.91	2.82
316	5.73	30.75	2.69	3.34	4.25	3.56	2.06	2.13	3.23
317	•	37.86	3.21	4.10	5.01	4.95	2.94	2.70	3.89
318	6.16	32.91	2.27	2.95	4.12	3.18	1.68	1.68	2.69
319	6.53	29.76	2.10	2.61	3.83	3.29	1.34	1.71	2.29
320	5.09	28.95	2.38	2.97	3.92	3.37	2.01	2.07	2.89
321	5.13	27.52	2.74	3.22	4.24	3.49	1.97	2.09	3.17
322	5.40	34.31	3.05	3.63	4.71	4.15	2.44	2.41	3.62
323	5.64	26.81	2.17	2.68	3.77	3.20	1.83	1.81	2.62
324	6.18	29.69	2.32	2.81	3.70	3.14	1.81	1.84	2.69
325	4.26	24.68	2.26	2.72	3.55	3.44	2.14	1.97	2.80
326	3.67	22.94	1.77	2.46	3.21	2.97	1.73	1.55	2.17
327	4.44	22.92	1.95	2.46	2.94	2.74	1.43	1.59	2.17
328	3.92	21.74	1.79	2.27	2.94	2.67	1.36	1.42	2.16
329	•	20.77	2.02	2.41	2.85	2.83	1.69	1.63	2.29
330	3.37	20.44	1.65	1.95	2.74	2.58	1.52	1.35	1.82
331	3.96	20.54	1.98	2.31	2.84	2.85	1.68	1.65	2.14
332	•	19.18	1.82	1.91	2.73	2.57	1.59	1.41	1.83
333	•	19.09	1.67	1.87	2.68	2.57	1.42	1.34	1.80
334	16.12	101.02	6.10	8.19	•	10.94	4.50	4.55	7.92
335	9.98	67.17	4.77	5.94	7.57	8.15	3.38	3.37	6.16
336	10.45	57.62	4.24	6.09	8.60	8.28	3.84	3.39	5.42

#	PDV	TWMX	LTH1	LTH2	LTH3	LTH4	LTH5	TTH1	TTH2
337	9.49	51.90	3.92	4.99	6.77	6.98	3.41	3.35	4.88
338	8.87	49.92	3.44	4.87	6.52	5.61	2.79	2.68	4.36
339	9.15	47.59	3.91	5.55	7.03	7.18	3.77	3.23	5.48
340	7.52	45.67	3.08	4.03	5.94	5.26	2.33	2.47	3.81
341	7.93	44.80	3.81	4.86	6.15	5.33	3.47	3.09	4.86
342	7.88	46.74	2.11	3.11	4.65	3.09	1.52	1.74	2.38
343	8.26	43.09	3.09	4.02	5.55	5.01	2.16	2.58	3.89
344	6.62	38.72	3.93	4.49	5.49	5.31	3.23	3.15	4.32
345	6.96	37.91	2.93	3.82	4.81	4.34	2.33	2.45	3.66
346	6.04	36.31	2.84	3.74	4.64	3.83	2.03	2.18	3.15
347	7.11	31.69	2.64	3.18	4.48	4.24	2.18	2.18	3.10
348	5.43	25.81	2.38	2.61	3.61	3.10	2.09	1.97	2.42
349	•	24.81	1.84	2.43	3.30	3.22	1.57	1.78	2.20
350	3.95	24.76	2.47	2.65	3.69	3.11	2.08	2.05	2.63
351	4.57	23.56	2.09	2.39	3.21	2.91	1.60	1.56	2.10
352	3.61	19.72	2.03	2.27	3.04	3.18	1.98	1.89	2.28
353	•	15.05	1.63	1.88	2.52	2.16	1.36	1.34	1.92
354	12.06	66.76	•	9.11	9.65	•	1.67	1.76	6.46
355	15.04	83.71	3.13	•	•	•	2.09	2.60	•
356	•	88.86	3.92	8.92	•	•	2.19	2.67	•
357	16.72	84.39	•	•	•	•	2.24	3.00	•
358	•	•	•	•	•	•	•	3.36	•
359	15.35	89.02	3.00	•	•	•	2.65	3.06	8.96
360	•	94.47	•	•	•	•	•	3.31	•
361	•	•	4.49	•	•	10.80	3.69	•	•
362	12.45	66.73	2.70	6.61	8.29	6.70	2.34	2.70	6.71
363	•	66.09	2.37	•	•	6.93	1.85	2.22	•
364	•	70.98	•	•	•	•	•	•	•
365	7.37	62.19	•	•	•	•	•	•	•
366	•	28.74	•	•	•	•	•	•	•
367	•	25.84	•	•	•	•	•	•	•
368	•	25.18	•	•	•	•	•	•	•
369	•	24.28	•	•	•	•	•	•	•
370	10.52	77.93	•	•	•	•	•	•	•
371	•	90.39	3.36	9.37	•	9.81	1.81	•	11.12
372	22.03	139.81	3.32	8.07	•	8.80	1.82	1.81	7.83

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
1	7.74	5.56	1.87	25.60	18.52	17.38	18.05	25.10
2	5.13	3.11	1.30	12.17	9.09	10.16	9.67	12.36
3	3.72	2.03	1.06	9.44	7.03	7.45	7.16	9.28
4	3.42	2.26	1.13	9.32	6.41	7.59	7.13	8.52
5	3.25	1.86	0.88	6.55	4.82	5.46	5.23	6.46
6	2.57	1.82	0.97	4.92	4.26	4.97	4.68	5.43
7	6.75	5.01	1.57	23.77	17.62	17.22	16.64	23.36
8	4.47	2.94	1.29	12.80	9.35	9.49	9.82	12.78
9	3.91	2.85	1.38	12.47	10.08	9.80	9.98	11.83
10	5.20	2.99	1.66	11.72	8.77	9.63	10.04	12.78
11	4.58	2.54	1.33	10.73	7.87	8.53	8.36	10.99
12	3.88	2.48	0.95	10.66	7.32	8.48	7.84	10.79
13	3.54	2.31	1.07	7.11	6.04	6.01	•	7.53
14	3.27	1.63	1.00	7.18	5.13	6.32	5.91	7.06
15	•	1.66	0.83	•	•	•	4.78	5.57
16	3.49	2.31	1.06	10.47	8.52	8.86	8.58	10.52
17	7.73	5.70	1.87	25.46	17.38	16.45	17.44	24.65
18	6.60	4.80	1.62	18.97	14.83	14.42	14.73	19.35
19	6.01	3.86	•	16.81	12.64	13.10	12.62	16.61
20	8.05	5.54	1.48	24.44	17.47	•	18.05	23.67
21	3.78	2.20	1.14	8.54	•	•	•	•
22	3.37	1.84	1.14	•	•	•	•	•
23	3.89	2.45	1.38	9.56	7.12	8.01	7.27	•
24	3.69	2.15	0.95	9.53	6.37	•	6.76	•
25	3.64	2.47	•	10.68	8.59	•	8.92	12.09
26	3.81	1.94	0.93	8.42	6.00	7.15	6.71	8.50
27	3.26	1.96	0.97	8.57	6.48	7.40	6.84	8.52
28	5.77	3.39	1.38	15.40	11.88	12.39	11.59	15.08
29	4.72	2.88	1.34	10.24	•	•	•	10.60
30	3.53	2.08	1.09	•	•	•	•	•
31	2.84	1.70	0.78	•	•	•	•	•
32	2.81	1.53	0.83	5.95	4.85	5.14	5.23	6.41
33	2.20	1.23	0.76	•	•	•	•	•
34	2.15	1.38	0.93	•	•	•	•	•
35	6.89	4.59	1.14	20.96	13.80	13.88	14.38	21.25
36	5.79	4.00	1.38	17.15	13.01	13.83	•	17.47
37	6.52	4.61	1.46	20.26	14.82	15.25	15.31	19.87
38	3.41	1.79	0.73	8.08	•	•	6.17	8.47
39	3.73	2.13	1.07	•	•	•	•	•
40	3.56	2.31	1.00	8.92	6.76	7.31	7.06	9.00
41	3.00	1.81	0.93	•	•	7.49	7.27	8.82
42	3.54	2.17	1.07	8.25	6.05	6.62	6.52	8.34
43	3.47	1.82	0.86	•	•	5.76	5.39	6.94
44	3.28	1.89	1.06	6.75	5.15	•	•	6.90
45	2.94	1.99	0.86	5.95	•	4.59	4.52	6.17
46	•	4.55	1.68	•	•	•	•	•
47	3.58	1.89	1.00	•	5.37	•	•	•
48	3.08	1.81	0.90	7.39	5.28	•	5.98	7.35

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
49	2.40	1.42	0.71	5.51	4.97	•	5.09	5.63
50	2.76	1.73	0.97	7.25	5.82	5.99	6.00	•
51	2.42	1.71	0.73	•	4.91	5.25	4.88	6.45
52	2.50	1.79	0.91	•	•	•	5.13	6.17
53	2.27	1.62	0.95	•	4.55	•	4.58	•
54	2.22	1.53	0.88	•	•	•	•	5.77
55	2.04	1.24	0.71	4.72	3.93	4.45	4.12	5.20
56	2.10	1.28	0.68	•	•	•	3.63	4.19
57	1.65	0.96	0.67	3.23	•	3.26	3.16	•
58	5.03	2.84	1.45	12.68	8.94	9.86	9.48	12.57
59	4.29	2.20	1.25	•	•	8.52	8.93	10.81
60	6.14	3.43	1.57	15.59	11.85	12.63	12.37	16.12
61	4.54	2.63	1.26	10.94	8.39	8.82	8.54	10.97
62	•	2.34	1.21	7.89	6.38	6.81	6.77	7.76
63	4.68	2.92	1.36	11.24	9.24	9.91	9.87	11.47
64	4.04	2.47	1.19	9.34	•	6.73	6.71	9.31
65	3.91	2.18	1.26	9.16	6.78	7.30	7.14	9.22
66	7.13	5.13	1.93	24.05	18.51	19.22	19.06	25.12
67	3.59	2.47	1.08	11.17	8.25	8.93	8.36	11.22
68	•	2.79	1.53	12.23	8.76	9.34	8.98	12.36
69	5.96	3.74	1.55	14.92	10.44	11.60	11.15	15.17
70	3.80	2.61	1.28	•	•	•	•	•
71	4.79	3.06	1.34	•	•	•	•	•
72	3.23	2.19	1.19	8.48	6.50	7.20	6.88	8.70
73	6.12	4.23	1.61	19.09	13.82	13.87	14.13	18.99
74	4.14	2.50	1.42	•	•	•	•	•
75	3.13	2.16	1.16	9.94	7.79	8.84	8.71	10.09
76	•	•	•	12.93	9.79	9.95	•	13.79
77	•	5.58	1.83	•	•	•	19.04	27.49
78	2.91	1.68	0.93	6.59	5.49	•	5.67	6.95
79	3.53	2.09	1.15	8.54	6.24	7.01	•	8.63
80	3.28	1.99	1.04	7.20	5.30	6.18	5.74	•
81	2.61	1.45	1.14	5.74	•	•	•	•
82	3.15	2.06	1.21	•	•	•	6.77	8.65
83	•	1.49	0.93	6.07	4.58	5.31	4.80	•
84	3.51	2.35	1.18	•	•	•	•	•
85	•	•	•	10.23	•	•	8.25	•
86	•	•	•	•	7.53	7.32	•	9.98
87	3.79	2.16	1.21	9.57	7.32	7.53	7.47	9.55
88	4.77	2.96	1.48	12.67	9.67	10.16	9.91	12.91
89	7.85	5.14	1.79	25.91	18.86	•	19.52	•
90	•	•	•	6.45	5.17	6.35	6.01	6.89
91	3.29	1.93	1.08	•	•	6.59	•	•
92	2.91	1.64	0.95	•	•	•	•	•
93	2.36	1.39	0.88	5.87	4.83	5.29	•	•
94	2.97	1.81	1.01	•	5.11	6.37	•	•
95	3.11	1.97	1.11	7.30	5.31	6.51	6.15	7.64
96	2.99	1.83	1.14	•	5.59	6.05	5.70	•

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
97	2.93	1.56	1.07	•	•	•	•	•
98	8.29	5.46	1.83	25.95	19.61	19.12	19.93	•
99	6.28	4.09	1.58	18.42	13.66	12.96	13.48	17.92
100	7.20	4.58	1.50	22.36	16.72	16.85	17.28	22.90
101	•	3.51	1.53	•	•	•	•	•
102	5.91	3.42	1.35	18.67	13.99	14.89	14.47	19.45
103	3.41	1.88	1.05	8.70	6.27	•	6.18	•
104	2.56	1.81	0.94	7.24	•	•	•	•
105	3.43	2.11	0.99	7.41	5.67	•	•	7.30
106	3.07	1.86	1.10	•	4.93	•	4.89	•
107	3.28	1.83	1.15	•	•	•	•	•
108	3.05	2.21	1.15	•	5.22	•	5.57	•
109	2.76	1.77	0.96	6.61	5.44	6.08	5.76	6.97
110	3.62	2.22	1.35	•	•	•	•	8.58
111	3.05	1.87	1.16	7.04	•	•	5.41	6.92
112	2.62	1.51	0.90	5.76	4.17	4.63	4.48	6.01
113	2.53	1.69	0.89	6.12	5.07	•	5.28	•
114	3.37	1.82	0.98	•	•	•	•	•
115	2.48	1.79	0.94	5.56	4.66	•	•	•
116	3.24	1.79	1.22	7.67	•	•	•	•
117	2.31	1.41	0.89	5.04	4.41	•	4.20	5.07
118	2.13	1.29	0.87	•	3.15	3.66	3.60	•
119	2.16	1.46	0.99	•	•	•	•	•
120	7.01	4.39	1.74	21.72	16.32	16.12	17.15	21.76
121	5.19	2.88	1.44	13.52	10.13	10.64	11.03	14.30
122	3.07	2.04	1.02	•	5.52	•	•	7.71
123	2.54	1.67	0.95	•	•	•	5.19	•
124	2.75	1.96	1.15	6.82	•	5.50	5.64	7.14
125	2.70	1.58	1.01	6.39	4.94	5.53	5.05	6.21
126	2.29	1.49	0.87	•	•	•	4.05	•
127	•	5.41	1.79	•	•	•	•	•
128	4.03	2.92	1.26	10.59	8.00	8.41	9.01	10.45
129	7.80	4.83	1.78	23.75	17.59	•	•	•
130	•	6.81	1.79	•	21.84	21.84	23.21	23.95
131	7.78	6.09	1.28	17.47	13.44	15.11	14.94	18.78
132	8.89	7.20	2.85	20.62	•	•	17.13	•
133	8.24	6.19	2.46	12.45	11.11	12.34	11.49	13.72
134	5.25	3.46	1.42	15.64	10.57	10.27	10.46	13.74
135	8.71	6.22	2.59	15.62	13.60	13.90	13.38	16.43
136	•	5.48	2.03	•	14.09	15.03	14.02	•
137	2.55	1.80	0.96	5.66	4.10	4.95	4.61	5.71
138	8.00	5.94	2.46	19.88	13.98	15.67	•	•
139	7.50	5.28	2.08	17.48	13.56	15.15	14.42	16.30
140	6.99	4.92	2.08	14.42	11.58	12.72	12.48	14.79
141	2.73	2.15	1.16	•	•	•	•	•
142	8.43	6.31	2.89	18.28	14.32	15.08	14.77	17.88
143	•	7.53	2.55	•	•	•	•	•
144	2.59	1.82	1.05	5.16	4.67	4.41	4.52	5.35

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
145	3.40	2.33	1.28	8.02	6.66	7.73	7.77	8.68
146	•	2.57	1.28	•	•	•	•	•
147	9.86	8.25	3.13	22.21	17.65	17.91	17.67	21.48
148	8.33	5.85	2.42	18.79	13.75	15.73	12.95	18.75
149	•	5.58	1.52	34.67	22.65	27.27	24.85	34.48
150	•	5.85	1.42	27.68	18.78	23.66	20.19	28.11
151	•	4.49	1.27	26.93	18.92	22.16	20.26	28.95
152	•	6.61	1.53	36.04	25.51	31.03	26.08	36.06
153	•	4.35	1.36	21.18	15.98	19.97	16.90	21.68
154	•	5.66	1.38	27.68	20.15	22.09	20.05	27.60
155	•	7.75	1.69	•	•	•	24.96	33.30
156	7.79	•	1.07	•	16.93	19.04	17.50	22.29
157	9.13	4.38	0.91	27.78	18.93	22.83	19.24	27.48
158	•	5.33	1.28	31.15	22.61	27.38	23.73	30.70
159	•	4.49	1.14	22.45	16.54	19.38	17.60	22.97
160	•	6.51	1.54	35.17	25.62	29.78	26.78	34.55
161	•	5.33	1.47	29.14	21.94	25.88	23.11	29.95
162	•	4.78	1.39	25.86	20.02	22.09	19.82	25.28
163	•	4.61	1.16	23.30	16.80	19.82	17.43	22.99
164	•	4.36	1.20	23.68	17.81	20.56	18.05	23.72
165	•	7.31	1.71	34.92	26.81	27.62	•	35.10
166	•	•	•	37.51	27.69	33.07	28.47	37.15
167	•	4.40	1.16	26.12	19.76	24.53	19.64	26.33
168	9.52	5.43	0.99	25.36	17.17	21.03	19.57	25.48
169	•	4.08	1.11	23.26	17.52	22.08	20.75	23.69
170	•	7.31	•	23.17	16.86	22.15	18.12	23.53
171	8.63	4.10	1.22	22.57	16.82	19.41	•	22.63
172	•	6.41	1.72	31.12	22.54	24.80	23.07	32.70
173	•	6.35	1.68	29.48	23.08	24.39	23.67	30.56
174	•	5.57	1.12	26.47	18.41	20.99	18.19	26.05
175	8.52	3.88	1.01	21.66	15.50	18.44	•	21.06
176	•	6.37	1.39	33.57	24.92	27.01	24.69	34.27
177	8.76	4.41	1.15	21.96	16.74	19.60	17.07	22.87
178	10.27	•	•	28.97	19.96	•	20.06	28.90
179	•	5.37	1.15	29.10	22.63	23.44	23.79	29.67
180	•	4.81	1.15	29.08	20.39	22.84	21.19	28.33
181	9.42	•	1.13	23.81	16.51	20.36	17.30	24.75
182	•	4.23	1.28	25.87	18.51	21.89	19.62	26.59
183	•	4.50	1.25	29.68	21.49	24.89	22.89	30.24
184	•	4.64	1.34	26.35	19.16	23.22	20.24	26.31
185	•	6.89	1.63	32.58	22.47	26.23	24.50	32.67
186	•	3.71	1.32	23.19	16.91	22.03	18.88	23.95
187	•	5.97	1.51	28.98	22.01	24.81	21.92	30.02
188	•	7.13	1.76	32.53	22.88	28.74	24.23	33.55
189	•	5.28	1.35	30.27	22.64	26.35	22.86	30.49
190	•	5.23	1.51	27.20	18.82	21.03	18.48	27.01
191	•	4.59	1.19	23.53	18.75	22.25	19.74	25.79
192	•	4.19	1.09	26.94	18.09	23.06	19.27	26.92

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
193	•	5.29	1.18	28.02	21.19	23.64	21.76	27.85
194	7.21	4.48	0.83	16.87	13.13	16.54	13.69	17.41
195	•	5.09	1.47	25.32	18.72	22.55	19.71	26.77
196	•	4.34	0.81	23.34	16.73	20.32	18.45	24.65
197	•	4.82	1.38	29.84	19.87	24.90	20.12	28.90
198	•	4.03	0.83	25.78	18.18	20.20	18.47	25.05
199	•	5.34	1.43	25.14	18.71	20.81	19.10	25.84
200	•	4.58	1.21	26.18	19.51	22.28	19.62	26.54
201	•	4.53	1.42	26.40	19.64	23.46	19.92	26.32
202	•	5.06	1.28	29.23	21.72	25.29	23.57	29.95
203	7.52	3.85	1.27	17.86	14.06	17.37	14.96	18.58
204	•	5.89	1.43	34.23	25.90	28.70	25.27	34.07
205	6.92	3.22	1.07	17.18	13.13	15.64	14.03	17.32
206	•	8.77	1.73	37.74	27.94	29.52	28.39	37.54
207	•	4.52	1.18	24.04	16.56	21.43	17.61	24.54
208	9.03	4.17	1.46	23.43	17.92	21.98	19.28	24.56
209	5.85	2.87	•	16.24	13.21	15.94	13.03	16.40
210	7.69	3.54	1.15	18.81	14.04	16.76	14.69	19.95
211	•	4.11	1.17	25.37	17.26	20.77	18.07	25.64
212	•	4.76	1.20	26.78	•	21.78	19.76	•
213	•	5.38	1.47	28.90	20.14	23.90	21.37	29.05
214	•	6.28	1.54	29.61	19.77	24.10	20.03	29.86
215	•	5.64	1.27	26.33	19.83	•	22.47	27.15
216	•	4.99	1.30	34.84	22.10	26.03	23.48	34.49
217	•	4.27	1.34	26.21	19.07	23.42	20.55	26.80
218	•	5.62	1.26	28.19	19.98	24.52	21.70	28.69
219	•	5.13	1.52	29.39	20.98	25.83	21.77	29.71
220	•	4.49	1.35	24.92	18.62	22.10	19.32	24.94
221	•	4.86	1.26	25.18	18.89	21.86	19.30	25.58
222	•	6.58	1.48	31.46	24.67	26.57	24.25	32.30
223	•	7.49	1.57	25.47	18.77	23.02	•	27.16
224	•	8.21	1.93	36.19	30.55	32.76	32.58	37.56
225	•	8.31	1.52	27.48	21.57	23.16	22.44	28.06
226	•	6.64	1.67	17.89	14.17	16.71	15.18	18.47
227	•	10.43	•	•	•	•	•	•
228	•	8.33	1.86	34.44	26.26	29.93	27.87	35.87
229	•	9.14	1.95	33.12	25.93	28.43	26.31	34.69
230	•	•	1.72	24.18	18.75	22.58	19.25	24.70
231	•	7.13	1.94	36.65	26.96	29.87	27.01	36.52
232	•	6.54	1.38	24.86	18.36	22.27	18.99	26.03
233	8.64	5.82	3.68	32.27	22.98	26.51	24.42	32.49
234	•	6.46	3.22	34.22	26.63	•	26.92	•
235	9.43	6.47	2.81	34.53	26.09	28.15	26.22	35.25
236	10.70	7.91	3.74	•	25.42	27.95	27.01	34.15
237	7.93	6.14	3.69	29.54	•	•	21.66	29.57
238	8.12	5.80	2.95	29.43	20.75	20.61	20.67	•
239	7.62	6.08	3.49	19.93	•	15.81	16.23	•
240	7.62	6.24	2.95	26.08	19.98	21.10	20.01	27.13

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
241	6.95	5.15	3.06	22.21	14.63	16.52	15.82	21.90
242	5.91	4.38	2.23	19.71	13.61	14.50	13.99	19.78
243	5.91	4.40	1.98	16.33	11.76	13.91	12.17	16.37
244	6.04	4.52	2.31	14.09	11.37	12.80	12.02	14.83
245	5.88	4.61	2.56	13.28	10.43	11.03	10.74	13.79
246	4.94	3.61	1.65	13.95	10.42	11.50	10.98	14.54
247	5.49	4.50	2.59	13.34	9.77	10.51	10.54	13.71
248	5.35	4.34	2.61	13.56	9.79	11.15	10.21	14.23
249	4.76	3.42	2.00	13.27	•	10.31	10.14	13.86
250	4.44	3.41	2.18	12.61	9.32	•	9.89	13.86
251	5.30	3.93	2.42	12.43	9.37	11.18	9.69	13.28
252	4.72	3.35	2.15	•	8.82	•	•	•
253	4.19	3.11	1.87	11.88	8.53	9.70	9.44	12.67
254	3.31	2.31	1.47	•	6.28	6.38	•	•
255	4.72	3.55	2.13	•	•	•	•	•
256	4.27	3.04	1.94	•	•	•	•	•
257	4.25	3.27	2.00	11.04	8.85	9.24	9.11	11.39
258	3.98	3.23	2.14	10.92	7.78	•	•	•
259	3.83	2.57	1.71	10.51	7.95	8.34	8.39	11.36
260	3.30	2.28	1.54	•	•	•	•	•
261	3.59	2.57	1.63	9.62	7.07	7.72	7.31	9.14
262	2.84	2.10	1.25	6.62	5.25	5.27	5.39	6.51
263	9.54	6.33	4.04	24.99	19.16	19.77	20.11	25.96
264	9.14	6.77	3.51	24.76	19.57	19.02	19.73	25.83
265	6.53	5.09	3.28	18.81	13.73	14.70	15.09	20.09
266	•	9.77	4.17	37.35	30.80	32.58	30.53	38.18
267	•	8.68	4.44	37.05	27.78	28.86	26.63	37.82
268	•	9.07	4.35	39.79	30.53	33.19	30.26	41.86
269	•	7.39	4.55	37.37	28.32	33.22	30.62	38.53
270	•	7.42	4.03	•	26.06	•	•	•
271	•	7.81	4.44	32.08	26.85	28.41	26.11	•
272	9.41	6.73	3.83	29.13	21.15	22.02	20.37	29.17
273	7.45	6.05	3.96	24.89	18.42	20.60	19.03	25.51
274	7.39	6.76	3.95	20.55	15.32	15.84	16.29	22.36
275	9.04	6.73	4.17	22.40	16.31	18.58	18.52	23.51
276	5.65	4.23	2.46	15.36	11.82	11.89	12.15	15.25
277	8.53	6.71	4.31	23.78	18.34	19.98	19.48	25.11
278	8.16	6.06	3.88	21.31	16.71	17.59	16.95	22.47
279	5.84	4.78	3.14	17.76	12.28	12.83	12.58	18.23
280	7.96	5.31	3.39	26.26	20.19	21.02	20.41	26.24
281	6.18	4.57	3.22	19.74	15.01	15.77	15.55	20.91
282	7.83	5.17	3.25	26.17	18.26	19.55	•	27.02
283	7.56	4.94	2.98	22.22	16.46	16.96	17.29	24.12
284	7.52	5.45	3.57	•	17.75	18.57	17.36	22.12
285	6.11	4.49	3.15	15.94	12.26	13.02	12.80	17.44
286	7.01	4.72	3.27	22.54	16.11	16.63	17.38	23.25
287	6.92	4.85	3.07	19.35	13.83	16.03	14.85	20.22
288	6.21	4.69	2.95	15.92	12.45	14.46	12.93	16.33

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
289	5.59	4.13	2.66	15.17	12.52	•	•	15.92
290	7.25	5.26	3.30	21.29	15.04	15.09	15.48	21.62
291	6.23	4.61	3.25	17.32	12.36	12.79	12.72	17.71
292	5.69	4.04	2.94	12.61	10.83	11.45	11.30	13.70
293	5.98	4.71	2.94	17.96	12.29	12.13	12.37	17.95
294	5.37	3.92	2.86	14.36	10.63	11.88	11.54	15.24
295	6.08	4.55	3.01	16.93	13.01	14.43	13.94	17.93
296	5.67	4.01	2.72	15.30	12.31	13.55	12.59	•
297	5.62	4.44	3.09	13.75	10.02	11.23	11.33	14.88
298	5.27	4.20	2.75	15.02	11.70	12.24	11.50	15.56
299	5.52	4.42	3.03	15.21	11.25	12.25	11.94	16.62
300	4.67	3.43	2.61	12.04	•	•	10.46	12.76
301	4.90	3.71	2.69	13.26	9.84	•	10.72	14.20
302	4.91	3.56	2.64	11.75	8.80	9.06	9.02	12.62
303	5.23	3.58	2.57	13.75	9.96	10.79	10.62	13.61
304	4.30	3.24	2.18	11.54	8.43	9.18	8.89	10.75
305	4.45	3.06	2.08	12.82	9.13	9.72	9.51	12.62
306	4.35	3.23	2.23	11.13	8.43	8.85	8.66	12.02
307	3.59	2.53	1.82	9.77	8.58	8.92	8.73	10.59
308	4.24	2.75	1.86	11.63	9.17	9.30	8.94	11.88
309	5.40	3.84	2.47	13.35	10.08	10.84	10.29	13.86
310	4.47	3.27	2.33	12.84	9.47	10.15	9.14	13.55
311	4.52	3.12	2.21	10.61	8.17	9.05	8.59	11.75
312	4.82	3.52	2.27	13.35	10.13	11.10	10.99	14.19
313	4.62	3.43	2.43	12.67	9.97	11.40	10.92	14.27
314	5.19	4.02	2.92	15.83	12.32	12.55	12.07	16.25
315	4.18	2.86	1.84	11.34	8.42	9.05	8.68	11.89
316	4.22	3.01	2.30	•	•	•	8.62	11.74
317	4.99	3.89	2.84	12.84	10.13	10.11	10.06	13.30
318	4.08	2.49	1.82	10.62	•	8.65	9.68	11.66
319	3.84	2.20	1.69	9.79	6.78	7.72	7.37	9.67
320	3.94	2.89	1.94	9.83	7.40	8.30	7.98	10.49
321	4.25	3.14	2.45	•	•	7.37	7.39	9.51
322	4.74	3.40	2.43	•	9.04	9.70	•	12.96
323	3.79	2.66	1.86	9.19	6.97	7.53	7.27	9.74
324	3.72	2.59	1.90	9.82	6.98	8.01	7.50	10.16
325	3.51	2.70	2.05	8.42	6.50	•	•	9.11
326	3.19	2.05	1.53	7.68	6.23	6.67	6.58	8.16
327	2.95	2.14	1.51	7.01	5.94	•	6.17	7.76
328	2.97	2.06	1.42	6.81	5.78	6.64	•	7.26
329	2.84	2.22	1.67	•	5.84	•	5.69	7.58
330	2.73	1.94	1.45	6.48	•	•	5.37	6.12
331	2.84	2.26	1.75	5.91	5.03	•	4.90	6.02
332	2.69	1.82	1.40	•	•	•	4.87	6.99
333	2.71	1.88	1.46	5.76	4.36	•	4.71	6.33
334	•	8.23	4.80	38.75	29.54	30.66	30.48	38.96
335	7.63	6.18	3.88	24.27	18.87	•	19.23	25.12
336	8.62	5.74	3.42	21.47	15.47	16.21	15.83	21.02

#	TTH3	TTH4	TTH5	PALI	PALII	PALIII	PALIV	PALV
337	6.76	4.99	3.46	20.64	15.17	15.54	15.49	21.63
338	6.54	4.24	2.72	17.09	13.13	14.09	13.89	19.09
339	7.05	5.79	3.46	17.14	12.35	13.47	13.08	18.82
340	5.98	3.93	2.54	16.22	12.31	14.12	12.73	17.08
341	6.08	4.60	3.46	17.36	12.39	13.88	12.26	17.15
342	4.57	2.56	1.78	13.59	11.08	11.39	11.60	13.63
343	5.56	3.84	2.75	15.12	11.12	11.06	11.94	15.71
344	5.46	4.37	3.16	•	•	11.98	10.93	14.46
345	4.84	3.60	2.50	12.96	9.61	10.32	10.15	13.98
346	4.65	3.10	2.32	12.45	9.52	10.16	10.44	13.06
347	4.48	3.27	2.31	10.76	•	8.59	8.34	10.93
348	3.65	2.47	1.93	8.44	6.36	7.39	7.08	8.65
349	3.31	2.22	1.75	7.60	6.08	•	6.70	8.09
350	3.65	2.60	2.22	•	•	•	5.69	7.35
351	3.15	2.19	1.78	7.08	5.82	6.17	6.12	7.39
352	3.05	2.37	1.80	5.81	4.24	•	4.84	6.25
353	2.51	1.83	1.37	5.15	3.91	•	4.08	5.57
354	9.48	•	1.57	17.53	•	•	13.88	17.34
355	•	•	•	•	•	•	•	•
356	•	9.08	3.14	•	•	•	•	•
357	•	•	•	•	•	•	•	•
358	•	•	•	27.47	20.07	•	21.90	27.47
359	•	•	3.07	•	•	•	•	•
360	•	•	2.97	•	•	•	•	•
361	•	•	3.53	27.03	19.67	•	•	27.13
362	8.15	6.08	1.91	19.41	14.74	16.14	14.24	16.39
363	•	6.36	2.46	•	13.80	•	13.85	16.90
364	•	•	•	•	•	•	•	•
365	•	•	•	•	•	•	•	•
366	•	•	•	•	•	•	•	•
367	•	•	•	•	•	•	•	•
368	•	•	•	•	•	•	•	•
369	•	•	•	•	•	•	•	•
370	•	•	•	•	•	•	•	•
371	•	9.55	2.62	26.75	21.97	•	21.33	•
372	•	7.92	1.98	•	•	•	•	•

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
1	9.30	9.63	8.86	8.55	8.68	7.79	42.58	36.13
2	5.43	5.56	5.33	5.71	5.39	5.02	23.22	20.40
3	3.35	4.16	3.73	4.01	3.98	3.91	17.31	15.31
4	3.45	3.55	3.83	3.98	3.54	3.64	17.31	14.79
5	2.31	2.64	2.57	2.65	2.48	3.56	13.08	12.25
6	1.95	1.85	2.13	1.98	2.04	2.59	10.14	9.66
7	8.64	8.17	8.92	8.63	7.87	7.09	38.92	33.13
8	4.29	4.48	4.62	4.47	4.35	4.66	22.94	20.86
9	4.53	4.82	4.73	4.59	4.14	4.19	22.26	20.40
10	4.64	4.91	4.74	4.83	4.77	5.63	22.82	20.18
11	3.89	3.94	3.94	4.05	3.79	4.80	19.44	17.27
12	3.61	4.19	4.24	4.53	3.72	4.25	18.55	16.00
13	2.80	2.89	3.04	3.00	2.83	4.01	15.30	13.47
14	2.69	2.85	2.79	2.90	2.71	3.65	•	12.57
15	2.00	2.14	2.31	2.19	•	•	11.31	9.71
16	3.40	3.65	4.03	4.08	3.42	3.65	18.78	17.55
17	7.55	8.63	8.58	8.66	7.82	7.74	40.24	35.05
18	7.67	7.72	8.00	7.81	7.09	6.65	35.05	31.52
19	5.71	6.28	6.32	6.13	5.68	6.27	31.83	•
20	8.14	8.87	•	9.14	8.35	7.89	41.19	35.90
21	3.00	3.22	3.58	•	•	3.89	19.35	17.08
22	2.70	2.88	•	2.84	•	3.86	14.65	12.68
23	3.34	3.60	3.23	3.72	3.28	4.02	17.64	16.00
24	3.17	•	3.37	3.58	•	4.05	17.60	14.63
25	3.74	4.21	4.22	4.20	3.84	3.87	20.96	•
26	3.06	3.31	3.36	3.26	3.04	3.87	•	14.22
27	3.11	3.35	3.56	3.59	2.98	3.51	•	16.09
28	4.99	5.53	5.67	5.51	5.21	6.31	29.46	27.05
29	3.59	3.93	3.78	4.21	3.64	4.74	21.14	18.68
30	•	•	•	•	•	3.63	•	15.72
31	2.28	2.61	•	•	2.24	2.83	•	13.47
32	2.36	2.57	2.64	2.75	2.41	2.92	•	10.45
33	•	•	1.94	2.01	•	2.13	•	8.63
34	•	•	•	•	•	2.43	9.29	8.71
35	6.97	7.50	7.63	7.77	6.15	6.92	35.58	29.89
36	6.36	6.85	7.36	7.44	6.38	5.80	31.24	28.04
37	6.98	7.02	7.22	7.27	6.89	6.61	35.05	30.79
38	2.97	3.21	•	3.31	3.30	3.51	17.19	14.99
39	3.51	3.40	3.61	•	3.58	3.79	16.06	15.11
40	3.36	3.32	3.56	3.55	3.23	3.67	16.02	14.19
41	2.88	2.89	3.18	3.49	3.23	2.99	15.62	14.32
42	2.83	3.22	3.17	3.39	•	3.77	14.42	12.35
43	2.81	•	3.12	3.07	2.76	3.54	•	12.87
44	2.81	2.92	•	•	2.84	3.31	13.01	12.36
45	1.98	•	2.40	2.42	2.28	3.02	•	9.25
46	•	•	•	•	•	•	•	36.37
47	2.74	3.04	3.13	•	2.97	3.74	•	13.81
48	2.56	3.00	2.94	2.95	2.73	3.02	12.29	11.37

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
49	1.75	1.98	2.12	2.12	1.82	2.57	•	12.06
50	2.31	2.66	2.66	2.70	•	2.81	•	10.84
51	2.42	2.61	2.62	2.61	2.50	2.50	•	10.13
52	2.33	•	2.46	2.47	2.29	2.64	•	10.74
53	2.05	2.31	2.45	•	2.10	2.45	•	•
54	2.03	2.07	•	2.29	2.19	2.37	•	•
55	1.70	1.94	2.09	2.05	1.70	2.19	•	8.30
56	1.42	•	•	1.72	1.53	2.26	•	7.79
57	1.28	1.37	1.54	1.46	•	1.79	•	6.21
58	4.35	4.78	4.49	4.96	4.61	5.07	•	19.85
59	•	•	4.13	4.30	3.95	4.29	21.05	19.78
60	5.43	5.52	5.44	5.33	5.67	6.22	32.14	27.72
61	4.19	4.07	4.20	4.18	4.21	4.69	19.49	17.51
62	2.96	3.18	3.10	3.02	2.80	3.72	15.41	14.66
63	4.35	4.45	4.87	4.44	4.04	4.68	21.86	20.53
64	3.10	•	3.38	3.49	3.08	4.05	16.76	14.46
65	3.25	3.69	3.67	3.74	3.37	4.16	17.29	14.82
66	8.86	8.61	10.47	9.17	9.24	8.16	41.02	35.66
67	3.43	3.79	4.02	4.24	3.68	3.89	19.55	16.51
68	4.36	4.50	4.55	4.44	4.14	5.47	21.81	18.93
69	5.25	4.98	5.06	4.89	5.01	6.37	29.41	24.53
70	•	•	•	•	•	4.14	16.80	15.31
71	•	•	•	•	•	5.15	21.41	17.89
72	3.18	3.27	3.27	3.15	3.21	3.45	•	14.54
73	6.46	6.61	7.48	6.64	6.34	6.98	29.62	29.67
74	•	•	•	•	•	4.46	19.57	16.67
75	3.47	3.77	3.62	3.79	3.52	3.50	18.66	17.44
76	4.81	4.95	•	•	4.66	4.75	22.47	19.98
77	•	•	•	8.93	7.89	•	43.45	37.76
78	2.43	2.83	•	2.70	2.58	3.35	•	12.71
79	2.88	3.28	3.24	•	2.94	3.76	•	13.39
80	2.48	2.82	2.74	2.79	•	3.71	•	11.91
81	2.11	•	•	•	•	2.80	13.08	12.31
82	•	•	•	3.39	2.91	3.62	14.68	13.09
83	•	2.35	2.44	2.54	•	2.84	•	11.12
84	•	•	•	•	•	3.62	13.67	12.92
85	3.14	•	•	3.63	•	3.99	•	•
86	•	3.62	3.59	•	2.89	4.28	18.56	15.62
87	2.87	3.40	3.20	3.34	3.06	4.21	•	14.17
88	4.20	4.97	4.87	4.92	4.37	5.15	20.82	19.68
89	8.44	8.64	•	8.38	•	•	40.99	36.89
90	2.58	2.66	2.74	2.76	2.52	3.46	•	11.88
91	•	•	3.18	•	•	3.58	15.72	13.58
92	•	•	•	•	•	3.05	•	12.75
93	2.05	2.39	2.54	•	•	2.54	•	12.24
94	•	3.09	3.21	•	•	3.24	13.86	12.06
95	2.73	3.03	2.78	3.14	2.77	3.43	•	10.87
96	•	2.62	2.58	2.55	•	3.08	14.33	12.62

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
97	•	•	•	•	•	3.21	12.86	12.01
98	8.77	•	9.79	9.20	•	9.14	42.51	37.99
99	6.72	7.35	7.73	7.22	6.51	6.62	32.37	28.89
100	8.21	8.33	8.47	8.38	7.67	7.46	38.15	33.98
101	•	•	•	•	•	5.69	29.78	26.00
102	6.93	7.96	7.91	7.95	7.14	6.26	35.21	30.91
103	2.80	2.91	•	3.20	•	3.89	•	13.51
104	2.22	•	•	•	•	2.93	13.05	12.35
105	2.71	2.78	•	•	2.92	3.62	•	11.50
106	•	2.72	•	2.92	•	3.17	•	11.91
107	•	•	•	•	•	3.44	14.50	13.56
108	•	2.57	•	2.71	•	3.39	14.03	12.70
109	2.42	2.77	2.84	2.94	2.54	3.11	12.48	11.63
110	•	•	•	•	3.03	3.89	16.49	14.13
111	2.73	•	•	3.04	2.70	3.31	•	12.11
112	1.92	2.10	2.03	2.30	2.10	2.82	11.15	9.85
113	2.13	2.24	•	2.25	•	2.62	11.53	10.10
114	•	•	•	•	•	3.90	15.25	13.09
115	1.92	2.27	•	•	•	2.88	10.33	9.72
116	2.66	•	•	•	•	3.50	14.31	11.89
117	1.88	2.10	•	2.44	2.02	2.51	•	•
118	•	1.65	1.71	1.72	•	2.38	•	•
119	•	•	•	•	•	2.51	•	•
120	7.69	7.27	7.92	7.34	7.41	7.53	32.80	31.08
121	5.32	5.69	5.73	6.33	5.57	5.20	26.82	23.22
122	•	2.83	•	•	2.70	3.67	14.22	13.09
123	•	•	•	2.46	•	2.95	12.44	11.56
124	2.19	•	2.59	2.85	2.25	3.11	11.79	9.60
125	1.96	2.31	2.44	2.59	2.05	2.98	11.53	10.23
126	•	•	•	1.99	•	2.36	9.18	8.45
127	•	•	•	•	•	•	•	•
128	3.64	4.09	4.51	4.50	3.84	4.41	19.20	17.23
129	8.53	8.18	•	•	•	8.21	41.96	37.03
130	•	12.63	11.50	12.34	12.48	•	•	•
131	7.39	7.77	8.66	7.87	7.69	7.95	30.63	28.32
132	8.02	•	•	9.09	•	9.39	36.55	32.81
133	5.71	6.12	5.27	5.66	4.74	8.63	29.28	27.44
134	6.10	5.86	5.86	5.54	5.54	5.51	•	26.53
135	6.65	6.70	7.35	6.79	7.09	8.39	28.91	27.35
136	•	7.09	6.43	6.74	6.80	7.20	•	•
137	2.03	2.36	2.54	2.51	2.13	2.62	11.32	10.38
138	6.79	6.88	7.08	6.75	6.88	7.97	36.72	33.65
139	6.41	6.52	6.93	6.92	6.60	7.48	32.60	30.07
140	5.81	5.76	5.86	5.91	5.85	6.95	27.96	25.67
141	2.40	2.64	2.59	2.89	2.92	2.81	•	•
142	6.78	7.18	7.73	6.60	6.71	8.38	•	30.68
143	•	•	•	•	•	•	•	•
144	2.61	2.62	2.41	2.51	2.15	2.71	11.89	11.54

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
145	3.42	3.39	3.50	3.55	3.30	3.37	16.25	14.43
146	•	•	•	•	•	•	14.93	13.51
147	8.53	8.34	8.83	8.96	9.14	9.55	•	•
148	7.78	8.05	7.93	7.84	7.74	8.42	•	•
149	13.09	13.79	13.81	13.29	13.41	•	61.95	54.74
150	11.83	10.79	12.75	12.12	11.30	•	56.81	50.80
151	11.43	12.82	12.85	13.13	11.27	•	52.69	46.72
152	14.03	14.70	14.42	14.96	13.29	•	66.96	59.25
153	9.84	10.77	9.95	10.51	9.99	•	44.92	40.56
154	10.61	11.34	11.20	11.60	10.99	•	57.12	50.58
155	•	•	•	14.55	13.90	•	57.72	57.12
156	•	•	10.07	10.20	10.01	•	•	•
157	10.24	10.78	9.95	10.89	10.59	9.49	49.94	44.66
158	11.92	12.39	12.70	13.10	12.09	•	54.38	50.62
159	9.16	10.38	10.28	10.46	9.55	•	45.88	43.15
160	14.94	16.04	14.66	17.15	15.23	•	65.75	58.05
161	12.89	13.76	13.85	13.74	13.11	•	55.06	51.75
162	10.43	11.05	10.80	11.23	10.04	•	50.01	45.47
163	9.96	10.42	10.54	10.42	9.99	•	45.50	40.43
164	10.59	10.64	11.11	10.89	10.29	•	48.06	45.30
165	16.01	17.11	17.09	•	16.24	•	64.14	57.88
166	14.11	14.95	14.86	15.51	14.74	•	68.80	61.01
167	10.55	11.43	10.89	11.50	10.93	•	51.68	46.07
168	10.03	11.43	11.07	11.09	10.52	9.82	48.32	42.54
169	9.58	11.08	11.09	11.73	10.83	•	48.75	39.62
170	10.17	12.01	9.68	11.66	10.95	•	46.40	•
171	9.94	10.45	10.03	•	9.98	8.77	•	40.12
172	12.30	13.13	12.89	13.17	12.69	•	61.38	55.41
173	13.16	13.06	13.23	13.34	12.25	•	57.87	54.50
174	12.25	12.23	11.77	12.38	11.28	•	50.13	45.44
175	8.67	9.19	8.99	•	8.80	8.89	44.20	37.80
176	13.58	14.67	15.63	15.24	13.91	•	56.05	54.14
177	9.82	9.62	9.72	10.12	9.53	8.96	•	36.10
178	•	12.11	•	12.30	11.33	•	53.79	•
179	12.59	13.13	13.54	13.36	12.44	•	54.63	49.58
180	11.46	11.88	12.25	12.50	10.14	•	•	51.61
181	9.53	11.00	10.90	11.11	9.74	9.69	46.60	43.50
182	10.69	11.04	11.15	11.11	10.41	•	51.77	47.34
183	11.78	12.92	11.80	13.47	11.98	•	56.29	50.37
184	10.72	11.53	11.91	11.66	11.24	•	49.94	43.71
185	12.90	14.91	14.80	15.09	12.94	•	59.96	55.04
186	9.20	10.17	9.75	10.42	10.59	•	47.41	42.21
187	13.44	13.54	13.55	13.77	13.37	•	54.17	49.51
188	14.08	15.01	14.53	15.06	14.26	•	62.02	55.50
189	12.26	13.57	12.99	13.89	12.95	•	55.00	50.22
190	10.11	11.56	11.05	12.05	11.26	•	53.81	48.21
191	11.15	11.15	11.12	11.20	10.96	•	49.98	46.86
192	10.98	11.23	10.78	11.22	11.30	•	48.72	43.85

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
193	13.53	14.49	14.28	15.15	13.79	•	52.27	50.66
194	7.22	8.02	7.53	8.07	7.41	7.27	35.71	32.58
195	10.95	11.96	12.09	12.29	10.83	•	52.75	47.52
196	10.10	11.02	10.89	11.06	10.13	•	45.11	41.44
197	12.42	13.99	13.86	14.18	12.81	•	58.14	52.01
198	10.19	10.43	10.14	10.50	10.03	•	49.68	46.88
199	11.21	11.87	11.93	12.40	10.94	•	51.05	46.26
200	11.77	11.68	12.17	12.17	11.30	•	51.71	46.25
201	11.03	11.74	11.34	12.24	11.28	•	51.58	47.31
202	12.54	12.77	13.41	13.41	12.81	•	52.66	51.61
203	8.08	8.55	8.78	8.74	8.09	7.82	38.34	35.78
204	13.43	14.46	13.01	14.70	13.23	•	67.62	62.02
205	7.20	7.91	7.60	8.17	7.22	7.23	34.01	33.08
206	15.29	15.83	16.73	16.04	15.74	•	69.65	64.66
207	9.91	10.14	10.16	10.43	9.88	•	49.59	43.99
208	10.62	10.83	10.33	11.15	11.02	9.72	•	44.11
209	7.06	7.16	6.97	7.15	7.14	6.01	33.53	•
210	7.72	8.16	8.02	8.20	7.87	7.76	38.74	34.74
211	11.28	12.38	11.82	12.76	11.33	•	50.55	45.97
212	11.47	•	12.23	12.69	•	•	50.12	45.74
213	11.78	13.29	13.45	13.43	12.31	•	52.83	48.67
214	12.32	14.54	14.15	14.25	12.55	•	57.47	49.67
215	10.58	12.02	•	11.91	10.94	•	53.41	47.69
216	13.32	14.13	13.53	14.15	14.05	•	59.27	50.94
217	11.79	12.21	12.23	12.76	12.21	•	55.55	50.50
218	13.36	13.62	13.50	13.38	13.23	•	56.86	53.53
219	12.45	13.68	12.54	13.30	12.82	•	56.97	50.02
220	11.34	11.92	11.26	12.33	11.31	•	47.39	43.63
221	10.74	11.07	10.82	11.01	10.83	•	47.88	44.76
222	14.09	14.54	15.06	14.52	13.85	•	62.82	57.14
223	12.85	13.53	13.88	13.58	13.00	•	59.39	51.33
224	17.39	16.68	17.85	17.00	17.32	•	•	•
225	15.02	14.16	14.45	14.08	14.26	•	•	51.09
226	7.68	8.16	7.68	7.79	7.44	10.24	34.55	31.77
227	21.28	21.08	23.11	21.55	21.18	•	88.43	•
228	15.97	14.47	16.06	15.24	15.78	•	74.87	68.66
229	15.22	14.42	14.73	14.55	13.81	•	69.39	60.56
230	12.10	12.85	13.47	13.13	12.21	12.47	56.97	48.60
231	15.18	15.31	15.57	15.36	15.18	•	71.79	61.98
232	10.19	10.56	11.07	11.12	10.38	11.34	52.36	45.68
233	8.08	9.61	9.84	9.69	8.72	•	39.19	33.10
234	8.40	8.92	•	9.00	8.54	•	40.41	36.09
235	8.55	8.99	9.06	9.23	9.11	•	43.29	35.19
236	•	9.25	9.61	9.86	9.79	•	37.90	31.38
237	7.73	•	•	8.35	7.77	9.35	36.95	31.88
238	7.63	8.62	8.68	8.67	7.96	8.49	31.58	25.12
239	6.15	6.78	7.12	6.85	•	7.81	25.40	23.20
240	6.69	8.14	8.73	8.72	6.92	7.88	31.76	26.50

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
241	6.07	6.35	5.95	6.32	5.89	7.28	26.73	20.09
242	5.23	6.01	5.91	6.14	5.34	6.22	24.59	18.85
243	4.15	5.11	5.14	5.79	5.37	6.31	20.90	16.94
244	4.77	5.14	4.82	5.34	4.94	6.37	20.26	16.99
245	4.72	4.85	4.73	5.08	4.90	6.24	19.18	16.51
246	4.03	4.41	4.68	4.81	4.19	5.33	18.12	15.65
247	4.36	4.74	4.64	5.15	4.41	5.81	18.49	15.50
248	3.87	4.54	4.47	4.95	4.11	5.62	18.65	14.98
249	3.93	•	4.19	4.67	4.24	4.76	16.62	13.39
250	3.45	3.91	3.75	3.98	3.60	4.48	16.26	14.12
251	3.94	4.21	4.08	4.59	4.19	5.37	16.40	13.38
252	•	3.82	•	•	•	4.85	16.38	13.56
253	3.61	4.11	4.03	4.57	3.86	4.21	16.70	13.30
254	•	2.70	2.69	•	•	3.40	11.97	10.74
255	•	•	•	•	•	4.78	16.61	14.16
256	3.58	•	•	•	•	4.34	14.68	13.18
257	3.53	3.63	3.53	3.97	3.45	4.25	14.68	12.73
258	3.53	3.83	3.63	4.05	3.60	4.29	14.69	11.72
259	3.14	3.53	3.68	3.73	3.32	3.82	14.05	11.73
260	•	•	•	•	•	3.49	13.22	11.69
261	3.32	3.45	3.30	3.59	3.16	3.60	13.19	11.22
262	2.38	2.31	2.17	2.45	2.41	2.92	10.21	8.55
263	7.72	8.19	8.39	8.39	7.86	10.15	30.10	26.06
264	7.73	7.88	7.69	7.56	7.53	10.44	32.61	27.97
265	6.14	6.07	5.75	5.98	6.20	7.71	23.85	20.11
266	10.39	11.15	11.47	11.58	10.69	•	•	•
267	11.90	12.50	12.70	13.79	10.97	•	43.99	37.70
268	11.60	12.97	12.33	12.80	11.36	•	49.01	42.20
269	10.63	11.17	10.94	11.07	10.69	•	•	38.22
270	•	9.77	•	•	•	•	38.11	36.82
271	10.25	11.04	11.36	11.15	•	•	38.27	•
272	7.51	8.53	8.47	8.35	7.69	10.87	33.88	27.19
273	7.15	7.23	7.60	7.78	7.06	8.64	31.38	26.39
274	6.40	7.26	7.57	7.26	6.66	9.77	28.43	23.56
275	6.51	7.23	7.65	7.06	6.75	9.79	29.03	24.27
276	4.59	5.43	5.65	5.27	4.49	5.79	19.76	16.21
277	6.60	7.80	8.02	8.48	7.65	9.62	29.20	25.58
278	6.48	7.17	7.34	7.46	6.64	9.17	27.38	22.67
279	4.93	5.70	5.28	5.94	4.98	7.39	21.33	16.57
280	7.07	7.91	7.57	8.13	7.56	8.59	30.08	24.51
281	5.16	5.66	5.94	5.85	5.45	7.13	25.01	20.38
282	7.49	7.95	8.09	•	7.41	8.02	30.14	24.52
283	6.26	6.97	7.39	6.92	6.78	8.12	28.09	24.28
284	•	7.27	7.10	7.23	6.54	8.19	28.38	26.00
285	5.16	5.58	5.34	5.61	5.25	6.69	21.17	18.42
286	5.79	6.64	7.21	6.75	6.26	7.27	28.43	23.82
287	5.59	6.34	6.33	6.83	6.14	7.33	24.16	19.57
288	5.10	5.79	6.19	6.01	5.10	6.63	•	19.63

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
289	4.91	5.17	•	•	4.59	6.55	21.06	18.25
290	6.24	7.28	7.05	6.85	6.19	7.53	26.92	20.14
291	4.51	5.31	6.04	5.55	4.39	6.94	21.74	17.64
292	5.10	5.33	5.14	5.33	5.41	6.63	19.03	•
293	5.37	6.01	6.13	5.96	5.51	6.55	22.42	16.76
294	4.59	4.90	5.18	5.06	4.79	6.46	19.09	16.49
295	5.21	5.83	6.01	5.82	5.38	6.64	22.65	19.69
296	5.28	5.70	5.71	•	•	6.08	20.37	17.40
297	4.57	4.52	4.64	4.88	4.80	6.15	18.51	15.12
298	4.50	5.28	5.10	5.46	4.91	5.69	19.47	16.32
299	4.50	5.34	5.35	5.73	4.60	6.47	19.57	16.62
300	3.79	•	•	4.42	3.94	4.75	17.44	15.53
301	4.33	4.52	•	4.59	4.39	5.25	17.92	15.86
302	3.83	4.19	4.42	4.39	4.22	6.06	16.82	14.18
303	3.93	4.42	4.22	4.48	3.99	5.63	17.52	14.20
304	3.59	3.98	3.77	3.95	3.82	4.66	15.05	12.40
305	3.98	4.20	3.94	4.10	3.86	4.47	16.21	12.88
306	3.73	3.88	3.81	3.99	3.71	4.61	15.28	12.75
307	3.37	3.29	3.66	3.49	3.36	3.63	15.49	15.31
308	3.49	3.57	3.63	3.61	3.32	4.31	16.04	13.41
309	4.11	4.49	4.46	4.53	4.31	5.78	18.13	15.14
310	3.68	4.36	4.22	4.62	3.99	5.08	16.44	13.88
311	3.81	4.41	4.16	4.15	3.82	4.64	15.52	13.57
312	4.11	4.56	4.75	4.48	4.42	5.04	17.49	14.02
313	4.07	4.79	4.52	5.23	4.52	4.73	17.57	15.15
314	5.11	6.01	5.88	6.03	5.08	5.72	21.10	16.84
315	3.52	3.80	3.58	3.80	3.65	4.29	14.04	11.96
316	•	•	•	4.05	3.53	4.46	14.81	11.97
317	4.01	4.17	4.36	4.50	4.27	5.42	17.84	15.11
318	3.44	•	3.61	3.80	3.45	4.19	15.21	13.42
319	2.51	2.96	2.97	3.03	2.95	3.97	13.98	12.09
320	3.08	3.46	3.44	3.62	3.28	4.57	13.23	11.38
321	•	•	3.71	3.67	3.68	4.82	13.61	11.45
322	•	3.92	4.18	•	3.60	5.50	16.61	14.06
323	2.85	3.19	3.59	3.79	3.01	3.92	12.37	10.48
324	3.47	3.67	3.47	3.79	3.55	3.96	13.44	11.39
325	2.92	2.89	•	•	2.89	3.69	11.56	9.76
326	2.51	2.76	2.77	2.91	2.52	3.54	10.65	8.85
327	2.53	2.70	•	2.81	2.47	3.13	11.02	9.44
328	2.38	2.53	2.51	•	2.49	2.99	10.76	9.20
329	•	2.48	•	2.71	2.49	3.38	10.21	8.71
330	2.11	•	•	2.34	2.14	2.89	9.64	8.26
331	2.18	2.34	•	2.34	2.18	3.05	9.74	8.58
332	•	•	•	2.26	2.24	2.80	9.93	8.48
333	1.96	1.93	•	2.11	2.14	2.92	9.21	8.17
334	9.64	10.79	10.97	11.01	9.57	12.67	44.90	37.02
335	7.10	7.84	•	8.22	7.07	8.98	29.41	25.42
336	6.02	6.01	6.83	6.68	6.57	9.58	26.28	21.79

#	PAWI	PAWII	PAWIII	PAWIV	PAWV	THMX	ALI	ALII
337	5.68	6.04	6.38	6.53	5.91	8.39	24.84	20.31
338	5.03	5.90	6.02	6.16	5.67	6.89	23.02	18.96
339	5.25	5.53	5.61	5.48	5.37	8.51	22.87	18.05
340	4.97	5.38	5.12	5.70	5.26	6.82	21.62	17.97
341	5.20	5.64	6.16	5.84	5.57	6.79	21.64	17.40
342	4.32	4.05	4.48	4.36	4.71	4.75	19.74	19.64
343	4.48	4.89	4.77	4.89	4.57	6.17	19.18	16.70
344	•	•	4.57	5.17	4.42	6.32	19.17	15.08
345	4.03	4.43	4.30	4.65	4.31	5.05	17.21	15.46
346	4.11	4.87	4.48	4.92	4.38	4.95	16.66	13.99
347	3.29	•	3.96	4.12	3.34	4.88	14.65	12.22
348	2.75	3.07	2.72	2.96	3.01	4.07	12.25	10.58
349	2.47	2.60	•	2.79	2.72	3.38	11.95	10.28
350	•	•	•	3.06	3.19	3.82	11.89	10.83
351	2.44	2.57	2.48	2.58	2.65	3.42	10.82	9.71
352	2.03	2.10	•	2.27	2.30	3.35	9.78	8.53
353	1.57	1.83	•	1.98	1.68	2.62	7.47	6.17
354	8.29	7.84	•	8.58	8.17	10.68	33.05	30.14
355	•	•	•	•	•	•	44.71	40.29
356	•	10.85	11.63	•	•	•	•	•
357	•	•	•	•	•	•	•	•
358	11.21	11.12	10.83	11.67	11.30	•	•	•
359	•	•	•	•	•	•	•	•
360	•	•	•	•	•	•	•	•
361	10.73	11.23	10.96	10.60	10.90	•	•	•
362	7.50	6.69	7.15	7.55	8.12	8.07	33.64	30.83
363	6.09	6.50	6.87	6.99	7.23	•	•	•
364	•	•	•	•	•	•	35.77	28.02
365	•	•	•	•	•	•	•	•
366	•	•	•	•	•	•	14.56	11.40
367	•	•	•	•	•	•	13.50	10.23
368	•	•	•	•	•	•	12.82	9.95
369	•	•	•	•	•	•	12.11	9.94
370	•	•	•	•	•	•	•	•
371	12.78	11.84	•	12.86	•	•	•	•
372	•	•	•	•	•	•	77.96	67.52

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
1	32.13	35.20	42.08	38.81	34.04	32.79	38.45	40.56
2	19.72	20.47	23.34	22.73	20.35	20.52	22.84	22.93
3	14.13	15.10	17.46	16.76	14.85	14.37	16.61	17.71
4	14.10	15.20	17.60	16.57	13.93	13.94	16.04	17.46
5	10.98	12.05	13.01	13.58	11.77	11.48	12.97	12.86
6	9.29	9.79	9.96	11.01	9.48	9.41	10.85	10.98
7	31.86	32.60	38.06	38.29	32.89	32.04	36.29	37.84
8	18.50	20.56	22.94	23.05	19.73	18.79	22.72	23.20
9	18.96	19.16	21.85	21.45	19.34	19.16	20.70	21.60
10	18.40	19.13	22.72	23.05	19.90	18.89	22.07	22.49
11	15.54	17.24	19.71	19.72	16.97	16.51	19.92	20.06
12	14.13	16.14	19.24	16.99	14.74	14.80	17.33	18.58
13	12.56	13.41	15.36	15.70	13.10	12.62	14.88	15.72
14	11.68	12.67	•	14.14	12.75	12.25	13.88	14.41
15	8.45	9.49	10.90	10.70	8.72	8.35	9.94	10.88
16	•	•	•	19.49	16.70	•	19.03	19.77
17	32.41	34.68	40.10	37.13	32.29	32.16	35.92	38.74
18	29.07	30.73	34.97	32.18	28.54	28.25	31.80	33.12
19	26.64	28.23	32.38	31.59	27.58	26.78	•	29.54
20	32.71	35.24	41.16	37.80	32.80	32.02	36.77	38.13
21	15.13	16.89	19.49	19.38	15.96	15.92	18.99	19.40
22	11.77	12.25	14.38	13.71	11.55	11.78	13.74	13.98
23	15.41	15.69	17.88	17.37	15.95	15.79	16.64	17.94
24	13.53	14.96	17.72	17.62	14.35	13.83	17.09	18.00
25	17.71	18.64	21.13	•	18.59	17.60	20.11	21.62
26	13.29	14.24	•	16.38	14.27	14.13	•	16.33
27	14.13	15.22	•	17.20	15.50	14.70	16.53	•
28	25.22	25.92	28.95	29.07	25.84	25.10	27.63	27.40
29	17.01	17.94	20.85	20.72	17.51	17.17	19.36	20.70
30	14.24	15.41	•	17.72	15.74	14.93	•	18.13
31	12.25	13.38	•	14.96	12.85	12.39	14.63	14.98
32	9.91	10.42	•	11.73	10.51	10.14	11.36	11.49
33	8.33	8.64	•	9.65	8.67	8.25	9.62	10.18
34	7.87	8.10	9.56	9.28	8.29	8.10	9.18	9.80
35	27.60	28.96	35.86	33.03	27.99	27.77	31.73	34.39
36	25.52	27.36	31.41	28.86	25.61	25.05	27.96	30.08
37	28.52	30.25	35.03	33.80	29.09	28.06	33.12	33.90
38	13.91	16.28	17.43	17.42	14.47	14.79	17.53	18.04
39	13.36	14.56	16.25	16.14	14.52	14.04	15.87	16.01
40	12.77	13.56	15.68	15.18	13.39	13.09	14.36	15.63
41	13.10	14.03	16.15	15.11	13.34	12.94	14.54	16.33
42	11.82	12.29	14.83	14.30	12.87	12.75	14.65	14.71
43	11.79	12.89	•	13.99	11.96	11.97	14.21	15.31
44	11.44	11.93	13.69	12.91	11.82	11.50	13.42	13.43
45	8.25	8.90	•	10.68	8.99	8.96	10.50	11.39
46	35.06	34.67	42.04	39.64	34.69	34.54	37.74	•
47	•	13.81	•	14.96	13.25	•	15.03	15.62
48	10.55	11.22	12.14	12.49	10.75	10.18	12.19	13.18

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
49	10.74	11.64	•	12.25	11.55	10.90	12.82	12.90
50	10.38	11.43	•	12.89	9.77	10.83	12.64	13.38
51	9.56	9.99	•	11.31	9.58	9.43	11.32	12.12
52	9.20	10.33	10.97	11.89	9.69	9.77	11.20	11.50
53	9.06	•	•	9.20	8.68	9.05	9.42	8.80
54	8.59	•	•	10.32	8.91	8.92	10.05	9.85
55	7.97	8.24	•	9.19	8.14	8.02	9.01	9.60
56	7.08	•	•	8.61	7.67	6.99	8.34	8.58
57	6.32	6.65	•	6.93	6.42	6.50	7.21	7.20
58	19.05	20.07	22.64	21.72	19.39	19.10	20.67	22.32
59	18.00	19.63	21.19	21.01	18.88	18.19	20.65	21.31
60	25.65	28.18	•	28.87	24.66	25.28	29.12	29.83
61	16.86	17.04	19.83	19.71	17.38	17.09	19.15	19.81
62	14.22	14.47	15.87	16.25	14.79	14.70	16.06	16.40
63	18.11	19.43	21.97	23.08	19.43	19.68	22.26	23.21
64	13.93	14.70	16.72	15.97	14.22	14.04	16.19	16.91
65	14.75	15.01	17.09	17.09	14.96	14.98	17.74	17.38
66	33.68	34.86	42.36	38.65	33.28	33.57	37.98	39.67
67	15.17	16.33	19.93	17.75	•	15.36	17.95	19.97
68	18.03	19.10	22.27	20.94	18.79	18.46	21.23	21.78
69	22.65	23.93	28.68	27.13	23.60	22.63	26.73	27.68
70	•	14.78	•	17.39	15.01	14.32	17.13	•
71	17.22	18.05	21.71	19.64	17.37	16.77	20.19	21.03
72	13.81	14.88	•	16.31	14.47	14.40	16.56	17.55
73	28.70	29.33	•	30.68	28.80	28.98	30.14	•
74	15.40	16.67	•	18.49	16.53	16.09	18.64	18.97
75	15.54	16.94	18.24	19.32	16.42	15.81	18.65	18.99
76	18.77	18.71	21.66	20.04	19.01	19.05	21.20	22.28
77	35.61	37.79	44.06	39.68	35.10	36.14	40.08	40.39
78	12.11	12.50	•	13.80	12.76	12.56	13.84	14.17
79	12.66	13.15	•	15.35	13.34	13.08	15.01	15.79
80	11.20	11.91	•	13.75	12.16	11.98	13.70	13.62
81	11.34	11.76	12.97	13.34	11.98	11.48	13.33	13.88
82	11.95	12.49	14.36	13.69	12.53	11.93	13.41	15.06
83	10.54	11.22	•	12.25	10.69	10.82	12.49	12.06
84	12.31	12.92	14.19	14.22	12.92	12.57	14.45	14.42
85	19.13	•	•	•	19.48	19.05	•	21.94
86	14.28	16.00	•	17.11	15.03	15.12	•	19.06
87	12.70	14.12	•	15.49	13.51	13.55	15.79	15.91
88	18.03	19.41	22.14	21.22	18.87	18.51	20.76	21.71
89	34.31	36.25	•	40.74	34.27	33.46	39.06	41.92
90	10.80	•	•	13.60	11.35	11.26	•	13.00
91	12.70	13.33	15.45	14.89	12.96	13.06	14.69	14.64
92	11.82	12.42	•	13.97	12.66	12.59	13.97	13.95
93	11.16	12.19	•	13.25	11.69	11.79	13.10	12.72
94	11.43	12.05	14.26	13.30	11.88	11.65	13.60	13.62
95	11.07	10.65	•	13.23	11.41	11.22	13.11	14.05
96	12.05	12.85	13.85	13.89	12.56	12.44	13.81	14.83

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
97	11.16	11.65	13.05	13.13	11.77	11.68	13.36	13.13
98	36.34	36.83	42.60	39.87	36.09	34.64	39.14	40.70
99	25.86	•	32.18	29.84	25.76	25.52	29.07	31.17
100	30.53	32.46	37.84	37.19	31.99	31.19	34.89	36.70
101	23.90	25.81	29.70	27.92	23.99	23.90	27.58	28.39
102	29.10	30.14	34.08	31.41	28.85	28.28	31.66	32.84
103	12.56	13.53	•	14.98	13.51	13.39	14.98	15.34
104	11.76	11.89	•	13.10	11.87	11.32	•	14.27
105	10.64	11.79	•	13.08	11.68	11.73	13.10	13.18
106	10.76	12.09	•	13.34	11.58	11.25	13.50	14.18
107	12.10	12.64	14.41	15.34	12.91	12.45	14.66	14.68
108	10.88	11.82	13.99	13.97	•	11.07	14.03	13.61
109	10.59	11.63	12.85	12.95	11.04	11.02	12.97	13.72
110	13.33	14.30	16.00	15.49	13.37	13.56	15.26	16.20
111	11.39	11.72	•	13.62	11.73	11.68	13.62	13.52
112	9.75	9.81	11.01	10.82	10.00	9.62	10.85	11.21
113	9.55	•	•	11.39	9.70	9.49	11.32	11.83
114	12.21	13.06	15.31	14.68	12.82	12.43	14.75	15.57
115	8.99	9.82	10.59	10.43	9.65	9.22	10.62	11.21
116	11.93	11.93	14.36	14.21	12.64	12.44	14.37	14.32
117	9.02	•	•	10.16	9.65	9.00	9.95	10.52
118	•	•	•	•	•	•	•	•
119	•	•	•	•	•	•	•	•
120	27.10	30.94	34.45	31.86	27.71	27.38	32.32	33.08
121	20.92	22.39	26.78	24.54	21.79	20.81	24.40	25.47
122	•	12.72	14.21	14.02	12.16	12.11	13.75	14.41
123	10.38	11.36	12.36	12.44	10.50	10.49	12.20	12.80
124	9.27	10.08	12.11	11.32	9.90	9.82	11.83	12.19
125	9.93	10.26	11.65	11.58	10.16	9.90	11.32	12.38
126	8.15	8.35	9.22	9.60	8.30	8.20	9.39	10.10
127	36.04	39.17	•	•	36.84	36.99	42.36	•
128	15.30	17.76	19.32	18.59	16.20	15.91	18.91	19.67
129	34.23	35.85	43.07	39.11	34.54	33.82	38.45	39.99
130	•	•	•	•	•	•	•	•
131	26.70	26.54	31.67	30.30	28.28	27.03	30.63	31.52
132	32.46	32.75	•	34.81	32.10	31.43	35.39	35.29
133	26.02	•	29.70	27.73	26.75	25.19	27.62	28.85
134	25.37	28.00	•	•	25.42	25.79	27.87	•
135	27.40	26.28	•	28.82	27.73	26.58	28.63	29.26
136	•	•	•	•	•	•	•	•
137	9.77	10.47	11.17	11.30	9.96	9.88	11.27	11.48
138	31.19	31.95	36.27	34.63	31.39	30.32	34.01	34.92
139	29.26	29.42	32.72	32.89	29.36	29.05	31.91	32.66
140	24.30	25.47	28.23	27.91	26.07	25.78	28.01	28.24
141	•	•	•	•	•	•	•	•
142	30.23	29.45	34.13	33.43	30.23	28.95	33.64	32.82
143	•	•	•	•	•	•	•	•
144	10.94	11.46	12.36	12.25	11.26	10.93	12.26	13.23

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
145	13.37	14.17	16.44	15.69	13.81	13.61	15.50	16.17
146	12.64	13.58	14.64	14.74	13.10	12.81	14.71	14.26
147	•	•	•	•	•	•	•	•
148	•	•	•	•	•	•	•	•
149	48.42	54.11	•	61.27	51.33	51.07	56.68	55.00
150	46.67	51.37	56.24	51.06	48.57	48.95	52.80	50.87
151	42.31	46.44	52.55	52.13	43.92	43.82	49.87	51.11
152	53.28	59.15	64.86	59.01	55.35	54.90	58.76	61.27
153	35.46	39.20	43.80	42.46	37.94	36.53	40.64	43.64
154	46.02	51.07	55.98	50.86	46.55	47.02	51.54	53.50
155	53.30	57.53	62.31	60.15	53.95	54.71	61.03	59.21
156	33.35	36.54	41.07	•	35.59	35.42	37.67	•
157	42.78	43.81	51.04	•	43.71	43.04	45.14	49.39
158	45.96	49.82	54.78	53.18	51.06	49.45	53.08	52.89
159	38.77	42.32	45.09	44.60	40.71	40.09	44.06	41.77
160	53.71	58.02	64.28	59.16	53.81	54.60	58.45	57.98
161	48.76	52.37	57.34	56.73	51.30	49.39	56.83	53.86
162	42.27	45.78	50.25	48.53	44.60	43.87	47.75	48.69
163	37.03	39.76	45.17	43.73	37.74	38.42	42.75	43.33
164	41.36	45.30	50.12	44.28	43.04	41.79	46.65	46.36
165	50.09	54.89	60.97	59.08	56.79	52.85	55.26	60.19
166	54.84	•	•	61.73	58.45	•	•	65.61
167	43.00	46.18	52.38	48.04	44.76	44.99	47.73	49.82
168	38.54	41.65	46.76	46.18	39.80	39.19	44.46	45.25
169	41.79	45.85	49.06	47.07	39.71	46.30	46.97	45.89
170	39.90	42.20	45.88	•	•	42.27	44.08	•
171	36.25	39.42	42.96	40.60	39.51	38.22	41.40	•
172	48.84	54.25	60.92	60.94	55.23	53.79	59.86	58.84
173	48.37	52.59	56.40	54.44	51.76	49.16	55.13	51.23
174	41.63	42.96	49.58	46.69	42.97	41.40	45.31	•
175	35.40	37.56	42.58	40.24	37.08	36.93	39.76	41.00
176	49.71	52.80	57.01	59.24	52.78	51.14	57.97	50.95
177	32.92	35.43	40.46	38.47	35.48	34.31	37.80	38.03
178	44.41	46.42	52.38	•	45.28	43.89	•	48.96
179	43.23	49.79	55.90	49.73	46.61	46.67	51.05	50.33
180	46.07	52.32	57.79	53.80	50.87	49.49	54.67	53.96
181	40.60	•	45.64	43.91	43.05	40.79	42.33	42.98
182	43.12	45.61	50.43	49.27	46.75	44.08	47.02	49.30
183	45.37	49.90	56.75	51.77	47.30	46.40	51.93	52.49
184	41.12	46.11	49.87	46.78	42.94	43.16	47.52	46.34
185	53.18	55.14	60.19	58.19	56.49	55.48	58.60	54.12
186	40.13	42.37	46.60	43.96	37.81	40.55	43.55	44.61
187	47.25	49.25	55.31	50.69	48.35	46.49	52.45	50.17
188	52.50	54.36	62.07	57.55	52.17	52.53	57.71	56.56
189	46.78	50.12	53.70	52.23	47.96	48.00	52.05	49.44
190	41.98	47.13	52.87	52.65	45.24	45.69	50.03	50.30
191	41.44	46.29	51.87	49.31	46.71	44.84	50.33	48.90
192	41.08	43.16	48.72	46.17	41.36	41.19	45.78	43.98

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
193	47.68	51.06	52.37	49.61	48.50	49.14	50.92	48.50
194	30.48	32.43	35.28	34.29	32.84	32.20	34.53	33.78
195	43.03	46.30	52.67	51.08	48.33	47.86	52.41	52.11
196	37.32	40.64	44.80	42.03	39.63	38.84	42.02	41.30
197	46.85	50.64	57.12	54.16	49.98	49.65	53.34	54.91
198	39.00	45.16	48.74	48.27	43.21	42.07	47.04	44.94
199	41.55	46.48	51.58	46.83	43.40	42.95	47.25	48.46
200	41.96	46.86	51.34	49.19	44.47	44.79	49.97	46.95
201	42.67	45.10	50.57	47.58	45.04	43.88	46.36	47.90
202	46.07	50.48	52.93	51.34	47.82	46.93	51.71	46.57
203	33.51	35.02	39.33	36.46	32.96	33.19	36.46	35.98
204	52.37	60.57	69.41	59.61	54.45	52.93	61.09	62.58
205	31.62	31.91	35.31	34.82	32.53	32.44	34.44	32.89
206	59.43	64.83	70.94	66.71	61.29	60.71	67.14	66.85
207	41.38	45.44	49.89	45.38	44.22	42.04	47.71	46.97
208	37.87	43.20	51.59	45.64	40.16	39.08	44.82	•
209	27.20	30.92	32.97	32.73	28.99	28.89	31.97	31.63
210	31.68	32.82	39.84	36.59	33.23	32.47	37.26	37.51
211	41.35	45.44	50.80	48.22	45.52	44.72	48.24	48.76
212	41.72	44.35	51.08	47.17	43.91	42.42	46.54	47.16
213	44.93	48.13	51.79	53.43	49.26	47.75	52.67	52.58
214	45.90	49.01	56.23	53.36	48.76	47.42	53.74	53.33
215	44.01	46.36	52.27	47.86	45.70	45.41	48.10	47.21
216	45.70	51.05	•	54.59	44.09	46.84	53.91	•
217	42.44	49.22	54.94	52.59	46.09	46.12	51.62	•
218	47.03	52.34	56.78	51.94	49.11	47.86	50.68	49.25
219	44.53	49.44	55.00	53.54	44.98	46.25	51.48	53.03
220	39.99	43.31	45.72	46.16	43.18	41.79	45.61	47.28
221	40.04	44.01	47.69	47.13	42.73	41.84	46.77	47.32
222	47.93	56.25	63.21	58.48	51.50	49.95	•	58.78
223	43.33	51.62	60.70	53.31	46.01	45.49	51.76	•
224	•	•	•	•	•	•	•	•
225	43.44	51.32	•	55.52	45.98	45.55	53.63	•
226	28.35	31.87	35.22	35.82	31.44	30.74	•	32.55
227	69.04	79.97	86.58	78.06	72.55	71.23	79.64	77.54
228	56.61	68.54	75.61	66.70	62.83	60.49	65.92	67.17
229	51.33	59.20	69.71	65.21	57.22	56.61	64.57	63.77
230	42.77	47.98	57.26	55.46	46.27	45.47	53.47	53.98
231	50.88	61.62	71.46	66.52	56.29	55.33	65.55	•
232	40.29	46.85	53.21	46.76	43.04	42.95	47.89	49.27
233	38.97	32.63	38.86	45.02	42.24	41.61	44.99	47.72
234	39.86	34.04	40.17	47.42	45.23	42.22	47.63	47.15
235	38.78	34.98	42.35	48.90	42.43	41.74	45.32	51.37
236	34.88	29.75	38.70	42.64	38.31	36.69	41.77	47.71
237	35.54	30.56	35.59	43.29	39.48	38.36	39.82	43.92
238	28.18	24.47	32.04	34.36	31.54	30.74	33.89	38.55
239	24.23	22.77	26.14	28.53	26.09	26.20	28.46	29.61
240	30.86	27.40	31.82	37.79	34.23	34.37	36.93	38.87

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
241	24.51	20.80	25.42	30.27	27.10	27.30	28.80	31.54
242	20.26	18.35	24.56	26.96	22.12	21.61	24.68	30.73
243	19.82	•	20.47	23.76	20.20	20.70	21.79	25.08
244	17.98	16.15	19.73	22.27	19.87	19.25	20.78	23.86
245	17.60	16.42	19.25	20.95	19.17	18.75	19.59	22.44
246	16.70	15.35	18.49	20.14	17.36	17.75	19.51	23.66
247	16.35	15.03	18.00	19.43	17.47	16.96	18.40	21.38
248	16.45	14.47	18.41	19.15	17.69	17.20	17.98	21.38
249	15.62	13.18	16.58	18.70	16.73	16.29	17.80	21.17
250	14.73	13.70	16.57	19.58	16.61	16.47	18.40	21.03
251	15.82	13.47	16.20	18.82	16.89	16.49	17.42	20.34
252	14.36	13.22	16.78	16.47	15.50	15.17	16.52	19.31
253	14.46	12.94	16.34	17.86	15.39	15.82	17.00	19.76
254	10.36	10.41	12.21	12.35	10.74	10.69	11.62	13.42
255	14.04	13.72	16.56	17.44	15.35	15.20	16.56	19.24
256	13.15	12.42	14.59	15.87	13.72	13.52	14.49	16.68
257	13.72	12.24	14.28	15.70	14.26	14.47	14.68	16.71
258	13.10	11.54	14.82	14.98	13.46	13.70	14.31	17.83
259	11.78	11.50	13.99	14.73	13.01	12.61	13.94	15.91
260	12.49	11.26	13.22	14.08	12.91	12.57	13.56	15.34
261	11.83	10.69	12.80	13.89	11.96	11.93	12.54	15.35
262	8.92	8.10	9.93	10.55	9.04	8.91	9.57	11.22
263	27.49	25.13	30.82	36.26	32.08	31.17	34.71	37.41
264	29.66	27.95	32.50	36.11	32.92	32.22	36.47	39.02
265	22.71	19.57	23.75	26.55	23.81	23.32	25.80	28.78
266	•	39.28	43.94	•	•	•	50.31	52.42
267	42.31	37.05	44.71	49.75	47.75	46.94	50.81	54.78
268	46.69	42.87	48.95	53.67	52.12	51.23	56.03	58.25
269	41.43	37.71	46.25	49.27	47.76	46.05	51.77	55.81
270	39.19	36.06	42.92	50.02	46.31	45.59	51.77	51.92
271	•	36.24	•	45.80	•	41.54	•	•
272	31.33	26.16	34.10	37.98	34.41	33.70	37.09	41.39
273	28.90	25.14	30.39	33.64	30.70	29.81	32.50	38.02
274	25.03	24.23	30.05	32.13	28.15	28.60	33.04	34.27
275	27.53	24.52	29.28	32.38	30.22	30.21	33.79	35.07
276	17.15	•	18.73	21.66	19.04	18.70	21.21	23.65
277	29.18	25.85	29.43	34.32	30.77	31.00	34.67	35.06
278	25.31	23.43	28.24	30.01	27.30	27.79	30.97	33.56
279	19.32	16.58	21.21	22.79	20.52	19.24	22.54	27.31
280	26.98	24.39	29.33	33.16	29.71	29.39	33.97	38.16
281	22.19	19.75	24.96	27.76	24.59	23.99	27.02	29.64
282	27.44	23.46	29.92	34.29	30.28	29.44	33.54	37.05
283	27.11	24.56	27.84	33.29	29.39	29.46	32.81	35.70
284	26.86	24.17	28.07	31.41	29.98	28.58	30.35	33.12
285	20.41	17.55	21.46	22.94	•	21.15	•	25.10
286	24.78	23.89	28.59	32.01	28.70	28.58	33.04	34.65
287	23.01	19.55	23.94	26.62	24.55	24.53	25.63	30.77
288	21.03	18.61	22.39	•	22.50	22.09	24.31	•

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
289	19.49	17.79	20.86	23.88	21.10	20.45	22.83	26.45
290	21.80	20.08	25.74	29.85	25.60	25.22	29.58	31.08
291	20.06	17.20	21.40	24.45	21.87	21.08	24.93	26.28
292	•	•	•	•	•	•	•	•
293	18.07	17.12	22.48	23.66	19.82	19.74	22.45	27.13
294	18.15	16.27	19.54	20.69	19.29	18.73	20.87	23.64
295	21.08	19.03	22.77	25.99	23.57	23.26	24.72	27.62
296	19.32	17.20	20.54	21.57	20.58	20.34	22.02	23.03
297	16.71	15.52	19.27	19.27	17.26	17.65	20.11	22.31
298	18.26	15.76	19.75	20.83	20.00	19.50	19.99	23.02
299	18.60	15.56	20.24	22.18	20.03	19.56	21.64	24.20
300	15.88	15.15	17.80	19.27	17.17	16.76	18.83	19.95
301	16.33	15.51	17.97	19.40	17.75	17.09	19.20	20.75
302	15.00	13.82	17.04	18.24	16.49	15.97	17.88	19.28
303	15.92	14.33	17.50	19.13	17.15	16.32	18.59	20.63
304	13.04	12.24	14.85	15.79	13.46	13.20	15.19	17.30
305	13.91	12.84	16.10	17.65	14.84	14.47	17.24	19.14
306	13.85	12.74	15.26	15.60	13.98	14.26	15.65	17.94
307	15.68	14.97	15.50	18.20	16.41	16.32	17.74	17.80
308	13.95	13.08	15.94	16.89	15.04	14.94	16.62	18.69
309	15.97	14.98	17.90	19.01	16.24	16.12	18.17	20.47
310	15.04	12.96	16.55	18.32	16.07	15.77	17.85	20.47
311	14.37	13.56	15.99	17.60	15.44	15.34	17.64	19.54
312	15.37	14.20	17.25	19.25	16.57	16.57	19.50	22.33
313	16.89	14.91	17.75	19.11	17.80	17.63	18.81	21.03
314	18.36	16.76	•	22.29	20.29	19.68	22.29	24.80
315	13.32	12.06	14.06	15.06	14.23	14.12	14.96	16.92
316	13.41	11.81	14.73	15.17	14.01	13.68	15.23	17.73
317	15.10	14.35	17.81	18.83	16.39	16.20	18.94	21.29
318	13.76	13.20	15.37	15.75	14.22	13.97	16.41	18.51
319	12.92	12.38	13.54	14.70	13.52	13.16	14.38	16.56
320	12.65	11.31	13.29	14.25	13.21	13.04	14.23	15.62
321	12.08	11.18	13.30	13.72	12.56	12.54	12.96	15.54
322	14.65	13.83	16.64	17.08	15.57	15.30	16.99	18.51
323	11.15	10.55	12.28	13.20	11.42	11.77	13.67	14.88
324	12.37	11.12	13.29	14.93	13.20	13.12	14.54	16.42
325	10.44	9.79	11.53	11.69	10.70	10.77	11.96	13.63
326	9.31	8.85	10.89	11.23	9.76	9.62	11.22	12.85
327	9.84	9.05	10.87	11.36	10.05	10.01	10.90	12.66
328	9.58	9.14	10.81	10.65	9.74	9.88	10.43	11.57
329	9.26	8.48	10.57	10.09	9.39	9.05	9.68	12.16
330	8.65	8.19	9.42	9.85	8.91	8.93	9.79	10.82
331	9.25	8.40	9.61	10.09	9.42	9.38	9.88	•
332	8.64	8.03	9.73	9.53	8.70	8.57	8.87	10.64
333	8.46	7.97	9.26	9.24	8.65	8.68	9.10	10.09
334	41.96	37.61	44.97	52.64	46.67	48.28	51.65	54.18
335	29.81	24.80	29.91	34.54	32.13	30.92	34.41	36.89
336	23.35	21.27	25.65	29.63	25.69	25.71	28.86	31.05

#	ALIII	ALIV	ALV	IL1	IL2	IL3	IL4	IL5
337	22.66	19.93	24.56	27.01	25.04	23.89	25.70	30.05
338	20.39	18.76	23.37	24.92	22.32	22.27	24.87	28.01
339	18.31	17.84	23.17	24.38	20.31	19.82	24.19	27.50
340	20.43	17.75	21.60	22.89	21.30	20.73	23.47	24.67
341	19.05	16.94	21.28	23.20	20.32	20.26	22.65	25.16
342	18.97	19.43	19.75	23.12	20.68	20.24	22.99	23.99
343	17.76	16.23	19.11	21.75	19.49	19.35	21.32	23.68
344	16.89	15.10	19.03	19.62	17.81	17.68	19.28	22.45
345	16.32	14.64	17.24	18.94	17.52	17.27	18.78	20.91
346	15.61	14.08	16.69	18.07	17.12	16.87	18.08	20.07
347	13.34	12.08	14.47	15.94	14.88	14.45	15.92	17.94
348	11.15	10.39	12.35	12.43	11.31	11.40	12.70	14.39
349	10.87	10.19	12.01	11.93	10.82	11.19	11.81	13.51
350	10.87	10.43	12.22	11.91	11.01	10.86	12.01	12.57
351	10.02	9.47	10.99	11.29	10.39	10.31	11.17	12.18
352	8.87	8.33	9.62	9.15	8.96	8.94	9.42	10.54
353	6.71	6.17	7.52	7.08	6.94	6.87	7.01	8.49
354	30.01	30.56	34.02	31.86	•	29.28	•	32.68
355	39.61	39.81	45.65	43.20	39.17	37.93	•	44.98
356	•	•	•	•	•	•	•	•
357	•	•	•	•	•	•	•	•
358	•	•	•	•	•	•	•	•
359	•	•	•	•	•	•	•	•
360	•	•	•	•	•	•	•	•
361	•	•	•	•	•	•	•	•
362	31.81	31.01	•	32.57	31.80	31.26	32.75	33.13
363	•	•	•	•	•	•	•	•
364	29.12	28.76	37.18	36.04	31.43	31.28	37.57	45.50
365	•	•	•	•	•	•	•	•
366	12.15	11.08	14.33	14.82	12.42	12.38	13.85	17.00
367	10.41	10.22	12.89	13.16	10.52	10.49	12.01	16.01
368	10.32	9.84	12.73	11.64	10.26	10.46	11.69	14.36
369	10.21	9.84	12.00	11.87	10.83	10.68	11.92	13.98
370	•	•	•	•	•	•	•	•
371	42.68	•	•	•	•	•	•	•
372	66.42	67.34	79.18	69.93	65.16	65.43	69.43	72.13

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
1	10.16	10.08	7.06	9.57	10.07	3.20	3.04	2.84	3.00
2	5.27	5.23	3.72	5.66	5.21	2.40	2.23	1.85	2.38
3	3.81	3.07	2.03	2.97	3.53	1.89	1.52	1.21	1.58
4	2.89	2.67	1.71	2.78	2.92	1.47	1.38	1.16	1.35
5	2.45	1.68	0.97	1.76	2.45	1.14	0.99	0.69	0.97
6	•	•	•	•	•	0.68	0.58	•	0.57
7	8.78	8.69	6.59	8.57	8.97	2.80	2.47	2.40	2.79
8	5.18	5.27	3.46	4.66	5.05	1.62	1.81	1.35	1.63
9	3.13	3.44	2.61	3.51	3.44	1.61	1.65	1.40	1.68
10	3.81	3.58	2.01	3.00	3.54	1.79	1.63	1.81	1.57
11	3.96	3.64	2.29	3.67	3.93	2.24	1.86	1.34	1.94
12	3.35	3.50	1.61	3.49	3.91	1.39	1.60	1.18	1.63
13	2.09	1.54	•	1.53	2.38	1.02	1.65	•	0.92
14	•	1.99	1.91	2.04	•	1.25	1.07	0.67	1.06
15	0.88	1.84	•	1.80	1.37	0.60	0.77	•	0.73
16	2.22	2.20	•	0.87	•	1.00	1.10	•	0.54
17	9.38	9.42	7.45	9.60	9.69	4.03	3.78	3.34	3.70
18	5.76	6.45	5.48	6.48	5.91	2.20	2.18	1.98	2.00
19	8.73	6.79	5.29	6.95	8.81	1.98	2.03	1.85	1.73
20	8.19	8.80	6.95	8.72	8.55	3.53	3.63	•	3.49
21	2.65	2.54	2.56	2.65	2.61	0.88	0.97	0.95	1.11
22	2.41	2.09	1.04	1.87	2.36	1.06	1.11	0.88	1.11
23	3.77	3.70	2.47	3.42	3.94	1.63	1.65	1.14	1.53
24	3.59	2.74	1.63	2.95	3.64	1.54	1.43	1.06	1.35
25	2.87	•	2.20	2.92	3.07	1.52	•	1.01	1.52
26	•	3.00	1.90	3.20	•	1.67	1.38	0.96	1.29
27	•	2.90	•	2.87	•	•	1.19	•	1.27
28	6.85	7.16	4.82	6.98	6.80	2.61	2.59	1.93	2.52
29	4.83	4.34	2.79	4.43	4.90	1.86	1.73	1.19	1.72
30	•	2.46	1.82	2.47	•	1.29	1.14	0.66	1.07
31	•	2.19	•	2.09	•	•	0.96	•	1.04
32	•	1.48	0.96	1.58	•	1.40	0.92	0.71	0.99
33	•	0.78	•	0.69	•	0.58	0.39	•	0.36
34	0.68	•	•	•	0.62	0.39	•	•	•
35	7.32	7.13	5.00	6.85	7.37	3.04	2.71	2.28	2.65
36	8.44	7.27	5.96	7.91	8.31	2.59	2.43	2.13	2.33
37	8.38	8.03	5.98	7.54	8.28	2.94	3.00	2.19	3.02
38	4.40	3.42	2.74	4.14	4.34	1.54	1.86	1.14	1.67
39	2.92	2.46	1.28	2.26	2.84	1.48	1.29	0.86	1.30
40	2.28	2.19	•	2.12	2.31	1.16	1.09	0.74	1.16
41	2.74	2.78	2.26	2.64	2.59	1.21	1.06	0.80	1.19
42	2.87	2.33	1.37	2.55	2.97	1.48	1.32	0.88	1.42
43	4.68	3.12	1.72	3.30	•	1.71	1.52	1.32	1.57
44	•	1.54	1.02	1.68	1.73	•	0.88	0.71	0.96
45	•	1.18	•	0.97	•	0.90	0.83	•	0.68
46	10.88	9.91	7.70	9.41	9.72	3.30	3.30	2.54	3.04
47	•	2.38	•	2.54	•	1.28	1.09	•	1.09
48	2.56	2.19	1.76	2.24	2.89	1.06	1.11	0.71	1.10

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
49	•	1.93	•	1.01	•	0.67	1.11	•	0.58
50	•	1.80	•	1.34	•	0.67	0.57	•	0.88
51	•	1.35	1.21	•	•	•	0.69	0.54	•
52	•	1.23	•	1.15	1.07	0.86	0.58	•	0.66
53	•	•	•	•	•	•	•	•	•
54	•	•	•	•	•	0.48	0.46	•	0.50
55	•	1.42	•	1.32	•	0.41	0.48	•	0.53
56	•	0.66	•	•	•	•	0.53	•	0.63
57	•	•	•	•	•	•	•	•	•
58	•	4.41	2.97	4.55	5.41	•	1.96	1.33	1.79
59	4.59	3.88	2.90	3.97	4.31	1.70	1.42	1.46	1.42
60	7.87	6.73	4.77	7.40	•	2.29	2.24	1.67	2.23
61	3.81	3.46	2.28	3.50	3.97	1.90	1.75	1.33	1.75
62	2.26	1.91	1.84	1.95	1.91	1.11	0.90	0.83	1.04
63	3.60	4.19	3.02	3.73	3.93	1.52	1.53	1.23	1.61
64	3.67	3.61	1.75	3.36	3.82	1.82	1.63	1.09	1.72
65	2.89	2.47	2.46	2.69	2.99	1.52	1.33	1.29	1.43
66	9.63	9.43	7.18	9.06	10.66	4.15	3.98	2.89	3.81
67	3.41	3.87	2.74	3.83	3.72	1.33	1.46	1.25	1.34
68	4.31	3.98	2.00	3.68	4.21	2.04	1.94	1.21	1.87
69	9.34	7.74	4.41	7.41	8.72	2.87	2.89	2.19	3.12
70	2.97	3.45	•	3.31	•	1.43	1.82	1.23	1.87
71	4.87	4.41	2.75	4.34	4.72	2.20	1.77	1.27	1.82
72	•	2.37	1.48	2.69	•	1.23	1.24	0.88	1.24
73	7.16	8.53	5.88	8.31	•	3.12	2.98	2.31	2.89
74	3.31	2.67	1.77	2.69	3.22	1.44	1.24	0.80	1.14
75	2.41	2.09	1.51	2.13	2.28	1.06	1.01	0.77	1.09
76	3.81	3.91	2.97	3.46	3.37	2.10	2.08	1.80	2.15
77	10.00	10.49	7.44	8.59	10.24	3.30	3.68	3.23	3.88
78	•	2.13	1.62	1.98	•	•	0.95	0.74	0.97
79	•	2.37	1.24	2.29	•	1.94	1.62	0.96	1.58
80	•	1.77	1.85	2.00	•	1.14	0.96	0.77	1.09
81	0.66	1.47	•	1.38	1.00	0.63	0.63	•	0.66
82	2.05	1.98	•	1.96	2.28	1.18	1.10	•	1.07
83	1.72	1.42	0.52	1.65	•	0.74	0.81	0.43	0.86
84	1.53	1.27	•	1.01	1.82	0.93	0.72	•	0.72
85	•	•	2.65	•	•	•	•	1.06	1.10
86	2.71	2.71	1.73	2.54	•	1.54	1.39	1.20	1.48
87	•	3.07	1.42	2.99	•	•	1.54	0.91	1.51
88	2.00	2.71	2.81	2.78	2.45	1.10	1.34	1.37	1.29
89	7.95	9.56	7.36	9.24	8.22	3.55	3.27	2.92	2.97
90	•	1.79	1.10	•	•	1.28	0.91	0.57	0.76
91	2.76	2.27	1.32	2.27	2.62	1.10	1.04	0.77	0.97
92	•	2.13	1.84	1.84	•	•	1.06	0.78	1.01
93	•	1.99	•	2.43	•	0.82	0.81	•	0.86
94	2.76	1.86	1.58	1.98	2.69	1.14	1.09	0.66	1.09
95	•	1.43	•	1.43	•	1.25	1.04	•	1.07
96	2.13	1.73	1.27	1.79	2.18	0.87	0.83	0.49	0.82

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
97	0.88	1.51	•	1.52	1.54	0.58	0.62	•	0.73
98	9.04	8.94	7.97	8.87	8.82	3.32	3.02	2.73	2.79
99	6.19	4.55	4.76	•	6.08	2.47	2.24	2.03	2.51
100	8.52	9.01	6.60	•	8.85	2.84	2.64	2.27	2.61
101	6.66	6.56	5.18	6.60	6.68	1.87	1.76	1.75	1.93
102	7.48	7.08	4.68	6.89	7.62	2.09	2.31	2.03	2.42
103	•	2.81	1.76	2.92	•	1.80	1.49	0.97	1.37
104	1.52	1.68	•	1.81	•	0.86	0.82	•	0.86
105	•	1.23	0.86	1.65	•	1.28	0.76	0.34	0.86
106	•	1.68	•	1.77	•	0.96	0.77	•	0.77
107	2.48	2.29	1.62	2.14	2.59	1.20	1.01	0.81	0.97
108	2.03	1.62	0.86	1.30	2.10	1.06	0.95	0.58	0.87
109	1.54	1.29	0.88	1.09	1.23	0.52	0.55	0.39	0.55
110	3.78	3.03	2.14	3.02	3.84	1.52	1.33	0.95	1.29
111	•	1.29	•	1.28	•	0.97	0.82	•	0.78
112	1.49	1.35	1.01	1.49	1.94	0.80	0.73	0.63	0.78
113	0.95	1.11	•	•	•	0.74	0.72	•	0.59
114	•	1.38	0.63	1.37	1.58	•	0.91	0.63	0.95
115	1.14	1.32	•	1.32	1.21	0.71	0.73	•	0.91
116	2.52	1.93	1.15	1.80	2.61	1.20	1.09	0.76	1.16
117	•	•	•	•	•	0.41	0.45	•	0.57
118	•	•	•	•	•	•	•	•	•
119	•	•	•	•	•	•	•	•	•
120	5.42	7.40	4.74	7.25	6.89	2.41	2.29	2.20	2.23
121	4.44	4.29	2.85	4.01	4.38	1.91	1.94	1.52	1.95
122	2.08	2.18	•	2.08	2.22	1.20	1.14	•	1.21
123	1.53	1.44	1.02	1.48	1.42	0.62	0.66	0.43	0.77
124	0.71	0.66	•	0.68	0.64	0.52	0.52	0.45	0.58
125	1.13	1.21	0.86	1.00	1.09	0.88	0.66	0.46	0.81
126	•	•	•	•	•	•	•	•	•
127	10.16	10.05	7.87	9.93	10.50	3.92	4.14	3.78	3.88
128	2.36	2.24	2.01	2.36	2.09	1.29	1.37	0.96	1.43
129	8.66	8.83	7.06	8.63	9.22	2.87	2.75	2.99	2.92
130	17.83	17.28	12.59	15.97	16.51	5.30	5.49	4.22	5.60
131	5.85	•	3.04	4.85	6.05	2.43	2.13	1.93	2.18
132	7.46	7.01	6.19	6.90	7.55	1.93	1.87	1.81	1.98
133	5.84	5.63	5.18	•	6.35	2.10	2.36	2.23	•
134	•	6.95	4.54	7.21	•	•	1.95	1.85	2.14
135	6.47	6.13	4.88	6.21	•	2.46	2.50	2.12	2.34
136	4.50	4.74	3.55	4.22	4.83	2.08	1.98	1.94	2.23
137	0.92	1.13	•	0.87	0.91	0.46	0.53	•	0.48
138	8.45	7.84	6.18	7.42	8.76	2.00	1.87	1.72	1.85
139	6.47	6.21	4.99	5.84	6.45	1.73	1.73	1.53	1.95
140	6.21	5.20	3.49	5.47	6.14	2.36	2.43	1.66	2.13
141	0.99	0.40	•	1.13	1.09	0.59	0.25	•	0.66
142	•	5.71	3.60	5.39	7.78	•	2.09	1.60	1.99
143	•	•	•	•	•	2.87	3.51	3.41	2.33
144	1.34	1.75	•	1.87	0.99	0.59	0.99	•	1.06

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
145	1.49	1.80	•	2.03	1.73	0.91	1.01	•	1.09
146	•	1.68	•	•	•	1.47	0.95	•	•
147	6.87	•	7.03	8.14	8.30	2.69	2.92	2.76	2.59
148	7.07	6.99	5.44	•	7.20	1.68	1.76	1.70	•
149	12.94	12.83	•	11.77	9.51	2.55	2.38	•	2.41
150	11.92	10.97	•	10.87	11.49	2.47	2.45	•	2.52
151	12.28	12.42	•	13.10	13.15	1.94	1.87	•	1.90
152	17.15	15.96	•	16.50	15.55	3.01	2.91	•	2.96
153	9.20	9.35	•	8.71	8.43	2.08	2.04	•	2.09
154	14.92	12.36	•	13.09	12.92	2.28	2.55	•	2.55
155	10.12	12.69	•	11.80	11.30	2.51	2.41	•	2.79
156	6.56	6.49	•	6.21	6.93	1.42	1.62	•	1.71
157	7.39	7.79	•	•	7.68	2.17	2.26	•	2.27
158	9.65	10.88	•	10.57	10.65	2.73	2.60	•	2.78
159	10.71	11.03	•	10.84	10.49	1.98	2.14	•	2.51
160	14.13	13.54	•	12.75	13.47	2.88	2.72	•	2.91
161	8.11	8.92	•	9.38	10.35	2.31	2.46	•	2.32
162	11.17	9.54	•	10.80	11.48	1.99	1.94	•	2.01
163	11.76	10.85	•	10.81	12.08	2.37	2.61	•	2.33
164	9.51	9.96	•	9.86	10.41	2.04	2.12	•	2.17
165	14.14	12.92	•	12.65	13.31	2.78	2.84	•	2.86
166	15.80	14.59	•	13.36	15.75	2.75	3.06	•	2.89
167	9.05	9.38	•	9.84	10.38	1.98	2.07	•	2.50
168	12.44	11.40	•	11.21	13.43	2.47	2.46	•	2.54
169	9.74	7.81	•	9.10	9.49	1.73	2.01	•	2.03
170	8.97	•	•	9.43	9.11	2.21	•	•	2.21
171	5.15	8.46	•	8.08	7.78	2.07	2.31	•	2.30
172	15.46	15.26	•	13.71	14.67	2.07	2.43	•	2.37
173	13.14	11.30	•	11.43	11.59	2.70	2.73	•	2.75
174	9.25	9.34	•	8.83	9.84	1.83	1.95	•	2.04
175	10.80	9.09	•	9.25	10.12	1.87	1.94	•	1.90
176	9.18	11.36	•	10.59	10.23	2.36	2.42	•	2.33
177	•	8.54	•	8.48	9.79	•	2.23	•	2.51
178	11.58	•	•	11.83	11.51	2.57	•	•	2.93
179	11.51	9.55	•	9.69	12.10	2.11	2.06	•	2.14
180	11.36	9.71	•	9.85	10.75	2.32	2.22	•	2.14
181	9.97	8.99	•	•	9.95	2.11	2.35	•	2.11
182	8.24	8.69	•	8.84	8.19	1.75	2.00	•	1.90
183	11.38	10.44	•	10.26	11.32	1.86	2.35	•	2.33
184	9.81	9.84	•	11.04	10.56	1.89	1.97	•	2.03
185	10.42	9.06	•	8.30	10.76	2.04	2.25	•	2.18
186	9.66	9.49	•	9.44	9.82	1.64	2.11	•	1.96
187	10.66	9.83	•	10.32	11.35	2.49	2.56	•	2.64
188	11.96	10.45	•	10.35	12.83	2.56	2.25	•	2.45
189	13.69	11.97	•	13.03	12.11	2.43	2.37	•	2.55
190	13.39	13.36	•	13.52	13.67	2.50	2.27	•	2.36
191	10.60	11.72	•	11.26	12.00	2.24	2.37	•	2.24
192	10.99	9.19	•	9.89	11.44	2.18	2.27	•	2.32

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
193	10.19	9.23	•	9.28	10.68	2.65	2.55	•	2.57
194	6.01	5.68	•	5.28	5.52	1.30	1.80	•	1.71
195	8.23	8.22	•	7.89	8.47	2.28	2.32	•	2.27
196	9.35	10.05	•	9.67	9.62	2.71	•	•	2.67
197	12.31	11.68	•	12.76	12.30	2.31	2.50	•	2.62
198	8.05	8.85	•	9.32	8.72	2.19	2.42	•	2.78
199	11.78	9.72	•	10.38	11.83	2.48	2.32	•	2.36
200	7.97	7.13	•	7.69	8.00	1.91	2.38	•	2.01
201	8.75	8.73	•	8.12	9.48	1.98	1.70	•	1.92
202	10.29	11.23	•	10.47	9.60	2.57	2.51	•	2.41
203	8.99	9.22	•	8.46	10.05	1.95	1.91	•	2.09
204	16.35	16.17	•	14.42	16.95	2.88	2.80	•	2.89
205	6.26	5.86	•	5.62	8.24	1.61	1.70	•	1.68
206	15.79	14.04	•	15.04	16.40	2.96	2.71	•	2.85
207	9.56	9.25	•	9.56	9.66	2.26	2.05	•	2.15
208	•	9.65	•	10.02	12.48	•	2.36	•	2.27
209	6.52	•	•	5.52	5.95	1.69	•	•	1.72
210	7.21	7.60	•	5.75	9.38	1.36	1.71	•	1.75
211	10.55	9.62	•	9.65	11.84	2.29	2.22	•	2.25
212	10.33	10.37	•	9.73	10.44	2.12	2.04	•	2.34
213	8.14	9.26	•	9.02	8.30	2.04	2.19	•	2.09
214	12.38	12.13	•	11.94	11.31	2.38	2.18	•	2.29
215	8.31	7.70	•	7.05	8.68	1.91	1.76	•	1.99
216	5.88	6.42	•	8.51	8.55	1.86	1.93	•	2.06
217	8.73	9.35	•	8.58	8.82	2.10	2.17	•	2.24
218	11.82	11.40	•	12.12	12.84	2.80	2.57	•	2.64
219	12.26	11.33	•	11.74	10.16	1.98	1.83	•	1.82
220	9.14	9.07	•	9.05	8.56	1.41	1.82	•	1.72
221	10.04	10.05	•	10.15	9.92	2.21	2.21	•	2.08
222	11.93	12.09	•	11.29	12.71	2.52	2.52	•	2.51
223	16.64	13.76	•	15.08	17.52	2.09	2.50	2.26	2.28
224	•	19.88	•	17.04	23.07	•	3.40	•	•
225	•	14.05	•	14.07	17.53	•	2.47	•	2.52
226	8.66	8.72	•	8.67	9.57	2.52	2.57	•	2.48
227	28.10	•	•	26.70	29.46	3.23	•	•	3.34
228	28.23	27.71	•	27.12	27.90	2.93	2.73	•	2.59
229	20.05	17.36	•	16.34	20.12	3.00	3.14	3.06	3.12
230	15.25	12.05	•	12.73	16.85	2.29	2.60	•	2.59
231	23.38	20.39	•	20.24	23.48	2.31	3.25	•	3.08
232	17.60	15.77	•	15.58	17.53	2.05	2.14	•	2.04
233	10.17	6.19	3.21	6.01	11.23	3.84	3.39	1.61	3.28
234	10.82	7.22	3.81	6.09	10.65	4.71	3.59	•	3.49
235	6.95	4.50	3.18	4.36	7.97	4.07	2.90	•	2.80
236	9.81	4.58	2.98	5.05	9.57	5.71	3.77	•	3.06
237	7.95	4.27	3.28	4.90	8.86	4.40	2.75	•	3.08
238	8.62	4.30	2.51	4.45	8.73	4.20	2.88	•	3.18
239	6.38	2.79	2.27	2.60	6.42	3.28	2.60	•	2.20
240	7.55	5.81	3.61	5.32	8.45	4.25	3.75	•	3.47

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
241	6.62	4.24	2.42	4.02	6.43	3.41	2.80	•	2.79
242	5.30	3.12	1.29	3.20	5.58	3.44	2.38	•	2.57
243	4.92	3.86	1.96	2.97	5.80	2.78	2.94	•	2.22
244	5.21	3.25	1.27	2.59	5.16	3.20	2.28	•	2.20
245	4.17	2.05	1.27	2.15	4.55	2.92	1.48	•	1.58
246	4.85	2.69	1.39	3.16	5.18	3.11	1.79	•	2.10
247	4.62	2.51	1.28	2.43	4.54	2.52	1.98	•	1.86
248	4.01	2.09	1.10	1.89	5.20	2.40	1.77	•	1.73
249	4.80	3.26	1.06	3.44	5.53	2.66	1.76	•	2.00
250	4.59	2.29	0.92	2.37	4.66	2.65	1.80	•	1.98
251	4.49	2.29	0.71	2.24	4.26	2.59	2.15	•	2.28
252	•	•	0.64	1.85	•	•	•	•	1.48
253	4.47	2.54	0.86	2.10	4.20	2.62	2.18	•	1.76
254	2.48	0.78	•	1.04	3.47	1.73	•	•	•
255	3.55	1.49	0.88	1.63	4.49	2.08	1.81	•	1.21
256	4.14	1.43	•	1.76	4.01	2.36	1.46	•	1.67
257	3.04	1.63	0.63	1.73	3.25	1.94	1.58	•	1.71
258	3.41	1.91	•	2.26	3.31	2.28	1.51	•	1.73
259	3.18	1.48	0.90	1.15	3.16	2.19	1.40	•	1.40
260	3.06	1.37	•	1.58	3.47	2.08	1.43	•	1.54
261	3.14	1.54	0.45	1.51	2.57	2.05	1.63	•	1.47
262	2.18	1.15	•	1.29	2.57	1.43	•	•	•
263	7.51	4.50	3.92	4.06	6.66	4.30	3.39	2.81	3.57
264	6.63	2.68	3.57	5.28	7.07	3.64	2.99	2.48	2.74
265	8.10	3.34	2.88	3.58	7.39	3.37	2.14	•	2.15
266	11.21	5.57	3.01	6.89	12.45	4.67	4.16	2.97	3.98
267	13.21	9.24	6.60	10.64	14.54	7.37	5.02	3.59	4.48
268	12.75	9.26	6.62	8.64	13.03	7.30	5.24	5.62	5.61
269	9.76	7.69	6.64	7.25	13.03	6.36	4.67	4.36	5.05
270	14.54	7.18	5.10	6.11	13.06	5.48	3.47	3.24	3.57
271	12.24	7.39	5.61	6.62	12.53	5.80	4.51	3.59	3.97
272	8.66	5.26	5.13	5.01	9.15	3.91	3.05	2.52	3.36
273	7.63	4.88	2.34	4.11	8.91	4.12	3.24	2.67	3.45
274	7.11	5.42	3.91	4.38	7.92	3.13	3.06	2.92	3.31
275	8.06	5.40	4.66	4.86	8.52	4.88	3.28	3.12	3.80
276	5.76	3.88	2.38	3.85	5.53	2.65	2.21	•	2.32
277	8.95	5.44	4.06	5.86	•	4.10	3.42	2.80	3.05
278	5.92	3.90	3.32	4.74	5.85	3.01	2.95	•	2.93
279	4.78	4.28	•	4.05	5.93	3.06	2.66	•	2.24
280	8.95	5.10	3.44	5.60	9.07	3.95	2.57	2.42	2.82
281	6.18	3.74	4.02	4.64	6.71	3.14	2.37	•	2.61
282	9.66	5.66	4.14	6.11	10.06	5.00	3.27	3.21	3.67
283	8.55	4.91	3.84	5.13	9.34	3.77	2.67	•	2.65
284	6.71	3.91	3.26	3.87	6.42	2.89	2.52	•	2.40
285	4.63	2.86	2.33	3.06	4.17	2.95	2.11	•	2.27
286	8.14	4.39	3.13	4.03	7.81	3.77	2.42	2.74	2.65
287	6.86	4.11	3.53	3.61	7.13	3.08	2.52	•	2.79
288	5.70	3.54	3.14	3.22	5.04	2.83	2.63	2.88	2.66

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
289	5.88	3.35	3.03	3.49	6.22	3.28	2.22	2.08	2.43
290	6.62	4.47	3.27	4.03	6.85	3.54	2.87	•	2.68
291	5.62	3.97	3.56	3.86	5.42	3.21	2.57	•	2.60
292	4.55	3.64	3.06	2.95	5.56	2.98	2.55	•	2.80
293	5.87	3.52	•	2.97	5.51	3.26	2.41	•	2.37
294	6.28	3.73	2.70	3.68	5.28	3.24	2.49	•	2.42
295	6.65	3.68	3.11	4.12	6.74	3.92	2.65	•	2.87
296	5.21	3.98	2.88	2.55	5.47	3.23	2.41	•	2.25
297	4.16	3.18	•	2.71	4.46	2.04	2.09	•	2.21
298	5.56	3.46	2.83	2.98	5.95	3.60	2.50	•	2.46
299	4.82	3.72	2.24	3.01	5.22	2.63	2.73	•	2.51
300	4.15	3.13	2.97	3.01	4.92	2.59	2.28	•	2.36
301	5.07	2.53	2.18	2.75	4.79	2.87	2.08	•	1.97
302	5.01	2.77	2.08	2.58	4.52	3.00	1.97	•	1.85
303	5.56	3.47	2.48	3.02	4.85	2.58	2.03	•	2.11
304	4.71	2.13	•	2.03	3.30	2.86	1.56	•	1.49
305	5.00	2.90	2.22	2.64	5.12	3.24	1.93	•	2.13
306	4.32	2.57	•	2.44	4.31	2.34	1.84	•	1.78
307	3.88	2.10	•	2.04	4.10	2.57	2.12	•	2.28
308	4.16	2.62	2.38	3.08	4.23	2.53	1.71	1.78	1.87
309	4.31	3.22	•	2.60	4.64	2.97	1.72	•	2.10
310	4.87	3.09	2.30	3.12	4.83	2.95	2.05	•	2.04
311	4.44	2.17	1.99	2.50	4.65	2.40	1.88	•	2.09
312	5.41	3.06	2.76	3.01	5.32	2.77	1.85	•	1.98
313	3.61	2.79	•	2.75	4.25	2.66	1.85	•	2.20
314	5.94	3.53	3.59	3.42	5.84	3.48	2.52	•	2.74
315	4.44	2.48	2.09	2.32	4.24	2.83	1.72	•	1.72
316	4.28	2.68	2.16	2.55	3.99	2.32	1.63	•	1.55
317	4.81	3.36	2.33	2.91	4.72	2.59	1.90	•	2.01
318	•	2.97	2.20	2.54	5.16	2.64	1.59	•	1.55
319	4.05	2.69	2.55	2.61	4.63	2.45	1.98	•	1.84
320	3.99	3.10	1.89	2.82	3.79	1.94	1.38	•	1.59
321	3.99	3.04	•	2.35	3.44	2.13	•	•	1.83
322	4.33	2.41	2.00	2.56	4.06	2.44	1.85	•	1.80
323	3.89	2.34	•	2.00	3.61	2.53	1.50	•	1.72
324	4.11	2.54	1.93	2.09	4.20	2.44	1.50	•	1.62
325	3.43	1.95	•	2.15	2.83	2.05	1.31	•	1.59
326	3.22	2.03	1.53	1.69	2.99	1.87	1.07	•	1.40
327	3.41	2.07	1.52	1.93	3.51	2.19	1.46	•	1.70
328	2.89	1.98	1.39	1.83	2.80	1.87	1.33	•	1.35
329	2.57	1.71	•	1.24	2.60	1.81	1.20	•	1.02
330	2.74	2.00	•	1.64	2.57	1.94	•	•	1.54
331	2.78	2.03	•	1.86	2.66	2.00	1.86	•	1.75
332	2.65	1.62	•	1.77	2.49	1.72	•	•	•
333	2.68	1.82	•	1.52	2.17	1.85	•	•	•
334	12.01	8.54	6.58	8.61	12.07	4.79	4.76	4.98	4.62
335	7.92	4.92	3.86	4.31	7.09	3.60	2.99	2.89	3.04
336	8.21	4.99	3.57	5.05	7.88	4.75	3.28	2.71	3.45

#	ALLI	ALLII	ALLIII	ALLIV	ALLV	ALWI	ALWII	ALWIII	ALWIV
337	7.30	5.12	3.72	4.30	8.04	3.75	3.04	2.77	2.85
338	7.18	4.17	3.58	4.08	7.72	3.34	2.46	2.31	2.41
339	5.79	4.06	2.64	3.40	6.41	3.01	2.31	2.13	2.66
340	6.50	4.23	3.29	4.15	6.62	3.03	2.49	2.59	2.24
341	•	3.43	2.88	3.02	5.93	2.60	1.87	2.02	2.17
342	6.92	3.62	3.42	3.41	6.61	3.16	2.77	2.97	3.19
343	6.71	4.19	3.33	3.97	7.16	3.25	1.92	2.27	2.21
344	5.34	3.44	3.17	3.39	4.64	2.52	2.13	2.23	1.92
345	5.14	3.60	2.73	2.94	5.19	3.27	2.06	1.81	2.25
346	4.13	2.92	2.60	2.82	4.29	2.17	1.87	•	1.97
347	4.23	3.06	2.58	2.83	3.79	2.40	2.33	2.47	2.24
348	3.53	1.98	•	2.41	3.65	2.83	1.74	•	1.85
349	3.62	2.27	•	2.47	3.02	1.91	1.54	•	1.19
350	2.73	1.67	•	1.63	2.74	1.96	•	•	•
351	2.79	2.04	•	2.12	2.81	1.94	1.98	•	1.47
352	2.32	•	•	•	2.19	1.50	•	•	•
353	1.81	•	•	•	1.76	1.36	•	•	•
354	5.60	•	•	5.57	5.14	2.61	•	•	3.45
355	•	•	•	•	9.57	•	•	•	•
356	5.48	5.02	5.47	•	•	2.78	2.70	2.52	•
357	8.05	7.42	•	•	•	4.52	4.71	•	•
358	6.97	•	7.15	•	7.55	4.16	4.14	3.97	•
359	•	5.04	•	6.41	4.69	•	3.23	•	3.56
360	•	•	•	•	•	•	•	•	•
361	•	8.29	•	•	9.35	•	4.73	•	•
362	5.41	4.92	4.25	4.50	•	3.37	3.03	2.45	2.80
363	4.80	3.39	•	•	4.90	2.34	•	•	•
364	•	•	•	•	•	•	•	•	•
365	•	•	•	•	•	•	•	•	•
366	•	•	•	•	•	•	•	•	•
367	•	•	•	•	•	•	•	•	•
368	•	•	•	•	•	•	•	•	•
369	•	•	•	•	•	•	•	•	•
370	•	•	•	•	•	•	•	•	•
371	13.76	13.10	10.40	•	•	3.08	3.16	2.98	4.25
372	15.76	13.53	11.20	12.97	15.22	3.06	2.59	2.54	3.03

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
1	3.07	30.32	23.93	23.02	23.93	29.99
2	2.20	17.25	13.88	15.08	14.13	17.57
3	1.77	13.56	10.92	11.50	10.87	13.58
4	1.40	12.52	10.73	11.09	10.47	12.54
5	1.20	10.93	9.76	9.76	9.48	10.68
6	0.66	9.84	8.73	•	8.62	9.43
7	2.67	28.51	22.37	22.42	22.58	28.15
8	1.58	17.33	14.24	14.03	14.47	17.58
9	1.63	17.86	15.03	14.83	14.00	17.46
10	1.66	18.36	14.35	14.43	14.38	17.97
11	2.18	15.03	12.72	12.94	12.91	15.20
12	1.56	14.50	11.77	12.39	12.16	14.61
13	1.19	12.45	10.87	•	10.88	12.29
14	1.24	11.77	9.65	10.21	9.76	11.39
15	0.62	9.81	8.19	•	7.92	9.08
16	•	15.55	13.67	•	12.86	15.15
17	3.98	29.93	23.49	22.60	23.76	29.92
18	2.08	24.85	21.25	21.42	21.22	25.52
19	2.07	24.05	18.92	20.44	20.38	23.58
20	3.70	29.51	24.38	24.28	23.85	29.00
21	0.90	14.98	12.91	13.08	12.68	14.85
22	1.15	12.09	9.33	9.60	9.16	11.73
23	1.62	13.19	10.52	11.54	10.71	13.30
24	1.56	14.32	11.54	12.01	11.48	14.07
25	1.52	16.20	•	14.51	14.03	16.61
26	•	12.86	11.07	11.83	10.90	•
27	1.27	•	11.86	•	11.76	13.46
28	2.54	21.92	17.55	18.42	17.71	21.51
29	1.75	15.59	12.90	13.86	13.04	15.69
30	•	14.18	12.26	12.47	12.01	•
31	1.21	12.42	11.27	•	10.43	12.31
32	1.40	10.13	8.59	8.76	8.39	9.94
33	0.57	9.01	8.07	•	8.14	8.95
34	0.36	8.71	•	•	•	8.83
35	2.88	25.80	20.37	20.37	19.74	26.28
36	2.43	21.79	18.75	19.13	18.59	22.25
37	2.89	24.56	20.56	21.25	20.80	24.49
38	1.63	12.50	10.23	11.36	10.75	12.39
39	1.48	13.32	11.93	11.82	11.45	13.09
40	1.14	13.48	11.49	11.67	10.87	12.90
41	1.21	12.52	10.76	11.01	10.87	12.92
42	1.35	11.44	9.57	10.45	9.70	11.92
43	1.95	11.17	9.35	9.86	9.37	10.82
44	1.20	•	9.42	10.09	9.34	10.88
45	0.87	9.56	7.69	•	8.00	9.44
46	2.92	•	•	•	•	•
47	1.16	12.34	10.51	11.25	10.51	12.63
48	1.16	10.28	8.57	9.00	9.10	10.17

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
49	0.78	10.62	10.32	•	10.38	10.96
50	0.50	11.82	9.93	•	10.13	11.63
51	•	9.86	8.48	8.83	•	10.33
52	0.63	10.05	9.10	•	8.72	9.67
53	•	8.85	8.90	•	9.80	9.11
54	0.59	9.00	7.93	•	8.06	9.11
55	0.40	8.45	7.28	•	7.53	8.08
56	•	7.72	7.12	•	7.09	7.87
57	•	•	•	•	•	•
58	1.93	•	13.93	14.63	14.16	17.37
59	1.76	16.35	14.13	13.83	14.33	16.49
60	•	22.78	18.89	19.12	19.18	22.44
61	1.81	15.44	12.75	13.22	12.35	15.15
62	0.91	13.38	11.96	12.01	11.43	13.51
63	1.53	17.80	15.82	16.38	15.41	17.97
64	1.75	13.13	10.21	10.12	9.86	12.83
65	1.52	14.24	11.30	11.79	11.30	13.81
66	3.93	29.42	23.95	24.75	23.87	29.76
67	1.27	15.11	12.06	12.72	11.97	15.03
68	1.85	17.48	13.55	14.24	13.67	17.67
69	2.74	20.28	15.58	16.71	15.34	19.79
70	•	13.75	11.45	12.00	11.17	•
71	2.05	15.49	12.58	14.55	13.41	15.97
72	1.29	13.22	11.32	12.25	11.69	13.30
73	•	24.81	18.80	17.28	18.78	22.45
74	1.21	15.10	12.49	13.43	13.01	15.15
75	1.02	14.52	13.43	13.58	13.67	14.42
76	2.13	16.91	13.69	14.10	13.71	16.89
77	3.23	32.68	24.37	24.43	26.26	32.88
78	•	•	9.90	10.56	10.23	•
79	1.94	12.61	9.98	11.08	10.56	12.48
80	1.14	11.72	9.42	10.12	9.72	11.50
81	0.53	10.71	9.85	•	10.08	10.97
82	1.20	12.21	10.42	•	10.36	12.03
83	•	10.23	9.01	9.43	8.99	9.98
84	1.10	12.00	10.35	•	10.75	12.48
85	•	•	•	15.65	14.52	16.45
86	•	14.40	11.40	11.32	11.73	•
87	1.62	13.03	10.83	11.11	11.17	12.96
88	1.10	17.60	15.03	14.68	15.18	18.35
89	3.26	31.08	25.15	25.46	25.19	31.08
90	1.38	10.89	9.16	9.38	9.55	11.03
91	1.07	12.68	10.21	10.47	10.61	13.01
92	0.96	11.65	9.47	9.62	9.96	11.68
93	0.76	10.97	9.94	•	10.10	10.92
94	1.23	11.53	9.24	9.90	9.75	11.73
95	1.29	11.25	8.87	•	9.29	11.09
96	0.88	11.89	10.02	10.92	10.51	11.92

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
97	0.80	•	•	•	•	•
98	2.70	30.93	24.56	24.77	25.46	31.87
99	2.43	23.41	18.80	18.88	19.39	23.81
100	2.81	27.71	22.07	21.94	22.07	27.63
101	1.82	•	•	•	•	•
102	1.87	25.67	20.81	21.98	21.14	25.71
103	1.81	12.63	10.16	10.50	10.45	12.87
104	•	10.99	9.93	•	10.26	•
105	1.14	11.58	9.56	9.41	9.39	11.62
106	0.86	11.62	9.72	•	9.86	11.73
107	1.27	11.60	9.88	10.47	10.12	11.76
108	1.11	10.26	9.38	10.26	10.23	10.96
109	0.62	10.88	9.30	9.60	9.81	10.99
110	1.48	12.90	10.32	10.71	10.16	12.64
111	0.88	11.65	9.49	•	10.21	12.02
112	0.77	9.37	7.72	8.36	7.59	9.35
113	0.62	9.58	8.62	•	8.68	10.08
114	0.91	•	•	•	•	•
115	0.69	9.34	8.00	•	7.91	9.39
116	1.23	11.91	8.99	9.72	9.85	12.56
117	0.53	9.09	8.14	•	8.42	9.32
118	•	•	•	•	•	•
119	•	•	•	•	•	•
120	2.51	26.09	21.64	21.04	22.83	26.98
121	1.94	19.60	15.96	16.38	16.53	20.47
122	1.21	11.93	9.34	9.27	9.86	12.06
123	0.67	10.71	9.56	9.25	9.49	10.75
124	0.57	10.10	7.96	7.97	8.02	10.21
125	0.93	9.84	8.35	8.96	8.22	9.80
126	•	•	•	•	•	•
127	4.41	32.53	26.87	26.41	26.56	32.38
128	1.19	15.50	13.50	14.17	13.69	15.45
129	2.84	29.83	24.40	24.71	24.59	31.15
130	4.80	41.99	32.51	31.82	33.89	42.91
131	2.46	24.62	•	22.12	21.15	25.14
132	1.91	27.07	23.02	24.40	23.21	28.09
133	2.28	22.07	19.10	19.91	19.12	22.03
134	•	•	18.00	17.62	17.22	•
135	2.37	22.18	19.73	21.46	19.58	22.72
136	2.36	24.15	21.03	22.64	22.22	23.99
137	0.41	9.65	8.58	•	8.40	9.33
138	1.87	27.13	22.40	22.42	22.35	26.78
139	1.68	24.30	21.74	22.68	21.64	24.89
140	2.43	21.71	18.59	19.27	19.82	22.91
141	0.74	•	•	•	•	•
142	2.07	25.24	21.14	22.97	22.52	25.84
143	2.89	•	•	•	•	•
144	0.76	10.65	9.80	•	9.82	10.46

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
145	0.99	12.06	10.56	•	11.58	12.76
146	1.52	•	•	•	•	•
147	3.08	28.62	24.43	23.79	24.05	28.21
148	1.82	26.36	21.46	22.09	•	26.73
149	2.07	43.29	33.94	•	35.28	41.41
150	2.48	39.78	32.96	•	34.09	40.06
151	1.80	37.51	29.81	•	30.94	37.85
152	3.35	46.38	37.61	•	36.26	45.22
153	1.86	30.53	26.76	•	26.68	30.13
154	2.55	39.57	32.42	•	32.55	39.16
155	2.73	44.81	40.94	•	38.11	44.29
156	1.20	30.05	26.66	•	26.06	30.07
157	2.22	35.59	28.96	•	29.27	36.22
158	2.79	41.38	33.74	•	34.17	41.35
159	2.04	31.53	27.58	•	28.27	32.52
160	3.29	44.74	36.44	•	37.11	44.48
161	2.40	38.77	33.55	•	34.48	39.61
162	1.73	34.83	29.51	•	29.79	35.28
163	2.28	31.60	26.41	•	27.21	31.96
164	1.99	33.47	29.50	•	30.46	35.25
165	2.87	44.93	37.41	•	37.56	45.01
166	2.50	47.88	39.03	•	39.58	47.78
167	1.93	36.56	30.34	•	29.92	36.15
168	2.28	33.99	26.40	•	27.99	32.88
169	1.70	35.14	28.13	•	30.81	33.23
170	2.19	33.30	•	•	28.01	31.87
171	2.07	32.06	27.33	•	27.57	31.91
172	2.12	41.20	34.34	•	34.91	41.11
173	2.70	38.73	34.48	•	35.71	40.50
174	1.84	34.47	29.34	•	27.96	33.96
175	1.91	30.59	25.56	•	26.25	30.12
176	2.10	40.34	34.38	•	33.33	40.17
177	2.39	28.70	24.58	•	24.35	29.36
178	2.55	36.48	30.12	•	30.42	35.85
179	2.03	38.18	33.94	•	34.02	38.99
180	•	39.24	33.56	•	33.56	39.72
181	1.94	33.78	27.89	•	27.80	33.66
182	1.86	36.52	31.01	•	31.22	36.84
183	1.94	38.62	32.83	•	34.45	39.65
184	1.97	34.61	28.96	•	29.19	33.41
185	2.04	43.99	36.81	•	38.08	44.36
186	1.91	32.93	28.71	•	27.26	31.90
187	2.58	39.75	34.03	•	34.68	40.59
188	2.64	45.11	37.90	•	38.75	45.28
189	2.27	39.12	33.32	•	33.51	38.77
190	2.42	38.21	31.18	•	30.97	37.36
191	2.01	34.37	30.60	•	30.60	35.52
192	1.89	34.75	28.01	•	29.07	34.65

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
193	2.78	38.56	33.85	•	34.73	38.34
194	1.73	26.97	24.20	•	24.30	26.12
195	2.27	36.26	30.90	•	31.34	36.55
196	2.60	32.33	27.22	•	28.16	32.70
197	2.26	38.16	31.45	•	31.29	38.01
198	2.28	34.82	31.67	•	30.17	34.13
199	2.41	34.27	29.98	•	30.30	35.01
200	2.46	38.11	32.20	•	32.11	37.87
201	1.73	36.42	30.75	•	30.53	36.16
202	2.33	38.32	33.80	•	34.56	38.93
203	1.49	27.27	23.86	•	24.61	27.56
204	2.89	45.22	39.77	•	39.24	45.23
205	1.85	25.95	23.69	•	23.74	26.84
206	2.78	50.29	43.08	•	44.17	51.48
207	2.07	35.34	29.01	•	29.57	34.95
208	2.23	34.11	29.65	•	29.86	34.26
209	1.71	23.04	•	•	21.39	22.87
210	1.41	27.31	23.08	•	22.89	28.42
211	2.21	36.45	31.29	•	30.57	36.89
212	1.98	33.78	28.31	•	28.57	34.33
213	2.09	39.33	32.29	•	32.82	38.60
214	2.25	39.23	32.32	•	32.31	39.20
215	1.92	36.58	30.72	•	31.62	36.55
216	1.90	42.85	32.74	•	33.78	41.99
217	2.18	37.56	32.99	•	33.66	37.29
218	2.76	39.49	34.35	•	35.72	40.04
219	1.82	40.52	33.95	•	34.05	39.70
220	1.59	32.69	28.30	•	29.24	32.39
221	1.94	33.08	28.94	•	29.35	33.38
222	2.63	41.83	36.40	•	36.76	42.45
223	2.09	37.50	30.60	•	31.88	38.55
224	3.16	46.29	40.30	•	44.86	46.64
225	2.50	37.76	31.73	•	34.22	38.22
226	2.34	25.83	21.66	•	21.95	25.78
227	2.33	•	•	•	•	•
228	3.00	43.91	36.60	•	38.73	44.90
229	•	36.62	•	•	37.57	45.68
230	2.55	36.96	29.57	•	30.18	36.66
231	2.20	46.52	37.98	•	37.40	46.32
232	1.72	33.95	28.38	•	29.09	34.84
233	4.25	43.33	34.83	39.20	35.24	43.40
234	4.48	45.19	38.59	40.34	36.80	45.41
235	4.61	47.15	37.51	39.67	37.68	46.74
236	4.85	40.44	34.34	38.12	33.54	42.01
237	3.73	41.50	33.74	35.54	32.62	40.13
238	4.16	35.92	26.74	28.14	27.05	36.43
239	3.36	28.63	24.86	25.40	25.06	29.24
240	4.64	36.01	29.18	31.62	29.59	35.86

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
241	3.63	30.22	22.07	25.06	22.98	28.93
242	3.40	26.55	20.29	22.02	21.18	27.17
243	2.98	23.26	18.50	20.40	19.36	23.58
244	3.02	22.14	18.49	19.90	18.88	22.03
245	2.78	21.60	17.57	18.38	18.50	21.97
246	2.74	20.00	16.89	18.12	17.39	20.67
247	2.99	20.77	16.86	17.46	17.38	20.77
248	3.03	20.96	16.35	17.56	16.91	21.10
249	3.16	19.08	14.92	16.28	15.37	19.32
250	2.62	18.40	15.32	15.62	15.39	19.15
251	2.74	18.73	15.31	17.42	15.72	18.32
252	•	18.37	14.93	15.34	15.03	18.92
253	2.56	18.49	14.42	15.49	14.70	18.26
254	2.57	13.70	11.68	10.97	11.86	14.27
255	2.41	18.44	15.49	15.18	15.40	18.46
256	2.81	16.64	14.19	14.16	14.35	17.09
257	1.81	16.85	13.91	14.69	14.28	16.62
258	2.01	16.67	12.77	13.89	13.61	17.34
259	2.34	16.16	12.77	12.63	13.11	16.07
260	2.38	14.88	12.70	12.96	12.80	15.10
261	1.75	14.78	12.31	12.90	12.14	14.51
262	2.34	11.22	9.60	10.04	9.58	11.04
263	4.90	33.62	27.74	28.96	28.65	34.82
264	3.71	36.10	30.07	31.56	31.66	36.68
265	2.90	26.80	21.20	23.47	22.63	27.52
266	4.93	49.65	42.89	44.78	42.78	50.29
267	6.86	49.33	40.52	42.18	39.18	49.75
268	6.95	55.72	45.19	45.92	45.19	54.73
269	7.14	50.27	40.39	44.64	43.30	50.86
270	5.63	42.63	39.01	40.59	39.09	48.33
271	5.74	43.55	39.82	41.49	40.25	43.71
272	4.03	37.68	29.80	32.49	29.10	38.04
273	4.71	33.96	28.36	30.72	28.18	33.37
274	3.69	30.38	26.32	27.59	26.63	31.89
275	4.73	32.60	26.55	29.18	27.82	33.04
276	2.65	21.74	17.91	18.56	18.01	21.07
277	3.68	32.05	28.08	30.95	29.20	32.66
278	3.09	30.50	25.74	27.41	25.61	30.93
279	2.89	24.56	18.78	20.12	18.81	24.35
280	3.67	34.08	27.49	28.30	26.50	33.07
281	3.37	27.47	22.28	23.95	22.38	28.01
282	4.06	33.94	26.35	27.89	26.34	34.21
283	4.26	33.28	26.10	26.29	26.45	33.04
284	2.58	31.46	27.70	28.03	26.60	31.44
285	2.77	23.76	20.14	21.83	20.10	24.35
286	3.97	31.30	25.88	26.21	26.33	31.64
287	3.38	27.01	21.18	24.24	22.31	27.38
288	3.11	24.46	21.25	22.94	21.17	24.64

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
289	2.99	23.67	20.38	20.49	19.33	23.08
290	3.08	30.47	23.14	24.29	23.25	29.31
291	3.02	24.87	19.30	20.47	19.30	24.63
292	3.57	22.01	18.71	19.13	19.20	21.43
293	3.07	25.30	18.99	19.08	18.81	25.05
294	3.24	22.29	18.15	18.45	17.99	22.70
295	3.89	24.78	21.47	22.70	21.42	25.21
296	3.15	23.19	19.07	20.66	19.21	23.16
297	2.39	20.60	17.20	18.58	17.25	20.93
298	3.19	21.73	17.88	19.42	17.92	22.13
299	2.74	22.26	17.93	19.35	17.97	23.09
300	2.70	19.05	16.72	17.04	16.99	19.97
301	2.65	20.20	16.93	17.03	17.57	20.98
302	2.69	19.17	15.63	15.99	15.58	19.56
303	2.89	19.93	15.64	16.67	16.31	20.15
304	2.27	17.09	13.98	14.26	13.89	16.90
305	3.14	17.80	14.45	15.29	14.73	18.01
306	2.74	17.34	14.34	15.02	14.31	17.12
307	2.46	17.54	15.95	15.65	16.15	17.81
308	2.77	17.80	14.82	14.96	14.64	17.78
309	3.53	20.17	16.70	17.24	16.78	20.10
310	3.03	18.16	14.94	16.10	14.81	18.62
311	2.43	17.63	15.25	15.51	14.94	17.90
312	2.93	19.78	15.27	16.09	16.07	19.89
313	2.76	19.24	16.30	18.26	17.02	20.12
314	3.45	23.13	18.64	19.18	18.26	22.22
315	2.74	16.35	13.14	14.01	13.37	16.39
316	2.48	16.77	13.11	14.27	13.35	16.92
317	2.57	19.60	16.76	16.85	16.18	19.74
318	2.79	16.98	14.66	14.60	14.93	17.41
319	2.65	16.21	13.17	13.35	14.13	16.10
320	2.33	15.34	13.03	13.73	13.01	15.36
321	2.31	15.80	12.60	12.65	13.22	16.14
322	2.15	18.75	15.82	15.94	15.67	18.80
323	2.77	13.86	11.80	12.18	12.04	13.88
324	2.46	15.42	12.49	12.96	12.65	15.29
325	2.08	13.08	11.11	11.35	11.09	13.10
326	1.94	12.06	9.89	10.14	10.52	12.48
327	2.00	12.19	10.35	10.75	10.47	12.38
328	1.95	12.03	9.96	10.31	10.45	12.47
329	2.00	11.63	9.65	10.01	9.98	13.71
330	1.84	11.01	9.07	9.09	9.36	11.15
331	2.19	11.08	9.36	9.76	9.74	11.34
332	1.66	10.98	9.07	9.30	9.28	11.32
333	1.82	10.73	8.98	8.91	9.03	11.05
334	4.42	50.67	39.41	41.67	40.67	51.11
335	3.19	33.02	27.08	30.44	27.62	33.98
336	4.08	30.01	23.67	24.77	24.01	29.44

#	ALWV	ALPI	ALPII	ALPIII	ALPIV	ALPV
337	4.07	27.74	22.63	24.13	22.29	27.42
338	3.73	25.16	20.84	21.71	21.19	26.23
339	3.47	25.08	20.44	20.41	20.75	25.59
340	3.69	23.70	19.69	21.83	19.99	24.03
341	2.81	24.19	19.21	20.32	19.34	23.97
342	3.65	21.74	20.79	19.54	21.19	22.09
343	3.34	21.73	17.93	18.33	18.47	22.18
344	2.65	21.02	17.25	18.65	16.98	21.04
345	3.27	19.21	16.62	17.29	16.64	19.59
346	2.50	18.63	15.39	16.60	15.77	18.84
347	2.58	16.76	13.78	14.71	13.67	16.60
348	2.39	13.88	11.71	12.17	12.08	13.86
349	1.83	13.43	11.09	11.57	11.79	13.74
350	1.72	13.44	11.69	11.55	12.04	14.06
351	2.02	12.44	10.93	10.78	10.93	12.88
352	1.60	11.17	9.45	9.61	9.66	11.29
353	1.49	8.55	7.07	7.64	7.23	8.63
354	2.95	23.39	•	•	20.15	23.76
355	2.42	•	•	•	•	•
356	2.88	•	•	•	•	•
357	•	•	•	•	•	•
358	4.33	37.56	29.22	30.32	28.66	36.74
359	3.51	•	•	•	•	•
360	•	•	•	•	•	•
361	4.97	•	29.60	•	•	37.94
362	3.41	26.86	23.63	24.35	23.55	26.73
363	2.24	27.77	24.25	•	•	27.85
364	•	41.37	32.00	30.46	31.22	41.93
365	•	37.87	27.31	26.44	28.07	37.82
366	•	17.17	12.76	11.98	12.31	16.94
367	•	15.22	11.18	11.64	11.95	14.89
368	•	14.83	11.51	11.58	11.95	15.07
369	•	13.69	10.93	11.01	11.29	13.65
370	•	50.88	34.77	33.74	36.00	51.26
371	4.27	33.00	28.46	29.15	29.54	34.78
372	2.42	•	•	•	•	•

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BIOGRAPHICAL SKETCH

Craig W. Oyen was born and raised in Williston, ND, where he attended public schools and graduated from Williston Senior High School. He may have been subliminally directed toward his interest in geology by his father, who gave him plenty of "field experience" in the subject. His father allowed him to pick rocks from the wheat fields on the family farm (near Zahl, ND) each spring after nature's annual frost-heaving of glacial till boulders to the surface of the fields. Another influence may have been a result of activity near his hometown. The oil industry was active in the Williston Basin in the late 1970s and early 1980s, and Craig occasionally worked as a "swamper," delivering drilling muds to oil drilling rigs in Montana and North Dakota.

Craig attended North Dakota State University in Fargo, ND, graduating with a major in geology and a minor in soil science. It was here that his interest in geology and paleontology was strongly influenced by the faculty of the Geology Department (particularly Drs. Alan Ashworth and Donald Schwert). After his graduation from NDSU, he began graduate studies at the University of Tennessee at Knoxville, and became interested in the fossil echinoids of Florida while working with Dr. Michael McKinney (a former UF geology graduate student of Dr. Douglas Jones). Craig decided to transfer to the University of Florida

for easier access to the fossil collection in the Florida Museum of Natural History and his field locations in the state of Florida. During his graduate work at the University of Florida he was employed as a graduate teaching assistant in the Department of Geological Sciences, and as a graduate research assistant in Florida Museum of Natural History (Invertebrate Paleontology Division) and the Department of Geological Sciences. As part of his teaching assistantship, he taught laboratory and/or lecture sections of Exploring the Geological Sciences, Physical Geology, Environmental Geology, Sedimentary Geology, Invertebrate Paleontology, Field Methods in Geology, and Clay Mineralogy. He also gave occasional lectures in several other courses. His research appointments involved fieldwork and fossil collection, preparation, and cataloguing for the FLMNH, and thin-section petrography and analysis of rocks to be used as concrete aggregates by the Florida Department of Transportation.

During the latter stages of his dissertation work, Craig was employed as a temporary Assistant Professor in the Department of Geology and Geography at Georgia Southern University, in Statesboro, Georgia. He currently is employed as an Assistant Professor in the Department of Geography and Earth Science at Shippensburg University of Pennsylvania, in Shippensburg, Pennsylvania.

Craig enjoys participating in many athletic activities such as cycling and basketball, though he has slowed down somewhat in recent years. During his time as a graduate student at the University of Florida he participated in intramural sports, usually on teams composed dominantly of geology graduate students (the “Psychotic Basement Trolls”). As a result of these “non-contact”

sports, he also kept the medical staff at Shands Hospital and the university infirmary busy repairing sports injuries including problems such as a cornea abrasion (basketball); a level-2 AC joint separation of his shoulder (football); numerous patella dislocations (basketball, racquetball); a minor ACL tear in knee (basketball); a chipped distal femoral condyle (basketball); a fragmented patella (basketball); a broken radius (basketball); a relocated tibia tubercle (and an associated tibia fracture and bone screws via reconstruction) (basketball); and numerous cuts and abrasions (basketball, football, cycling). Fortunately, with age comes wisdom, and he currently exercises more cautiously than before.

Craig is a member of the following professional organizations and honor societies: the Paleontological Society, the Geological Society of America, the Florida Paleontological Society, the Pennsylvania Academy of Science, Sigma Xi, Sigma Gamma Epsilon, and Phi Kappa Phi. He also serves on the board of directors of the Marine Science Consortium, Wallops Island, Virginia.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Douglas S. Jones, Chairman
Professor of Geology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Geological Sciences in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May, 2001

Dean, Graduate School